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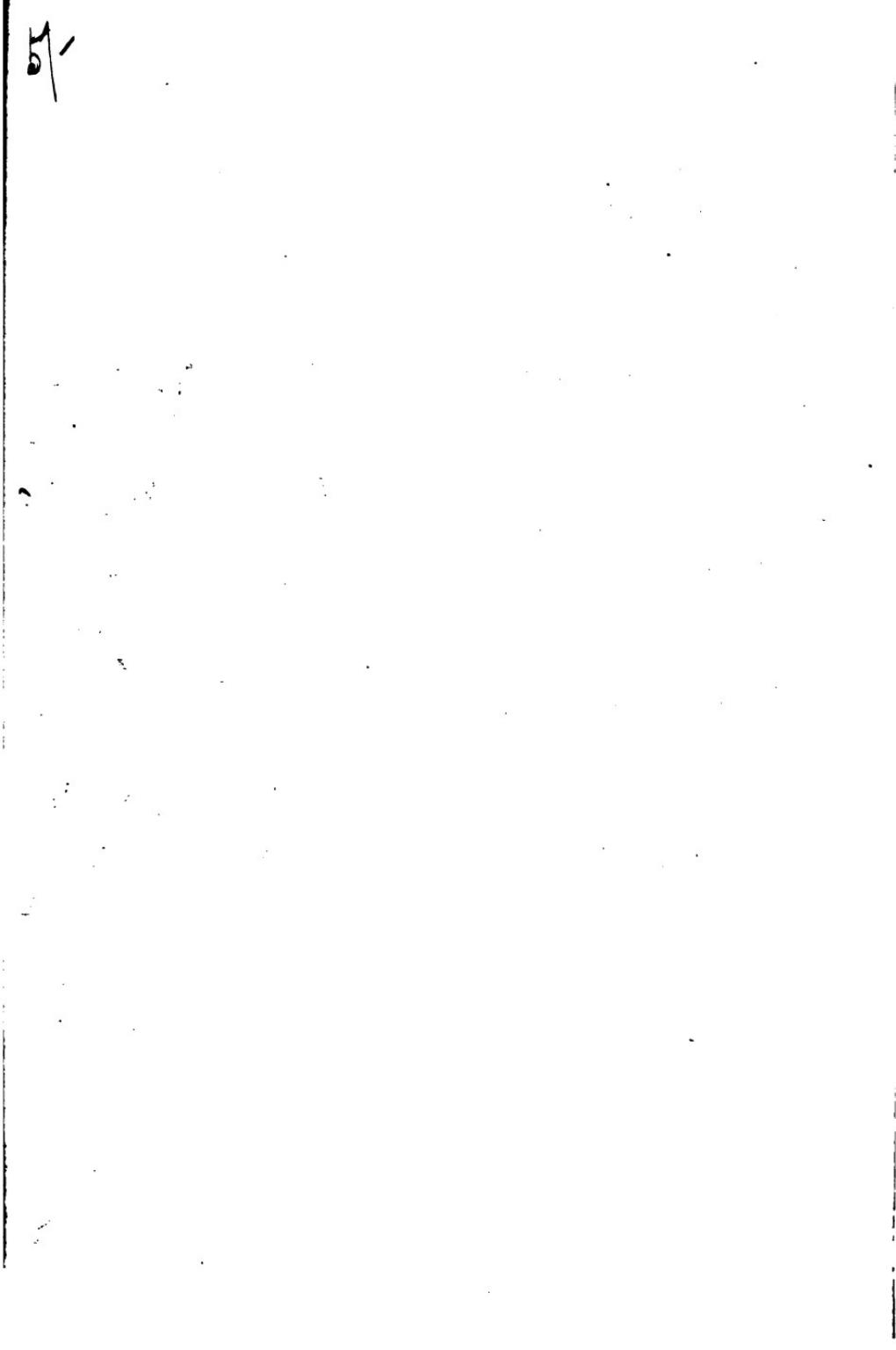
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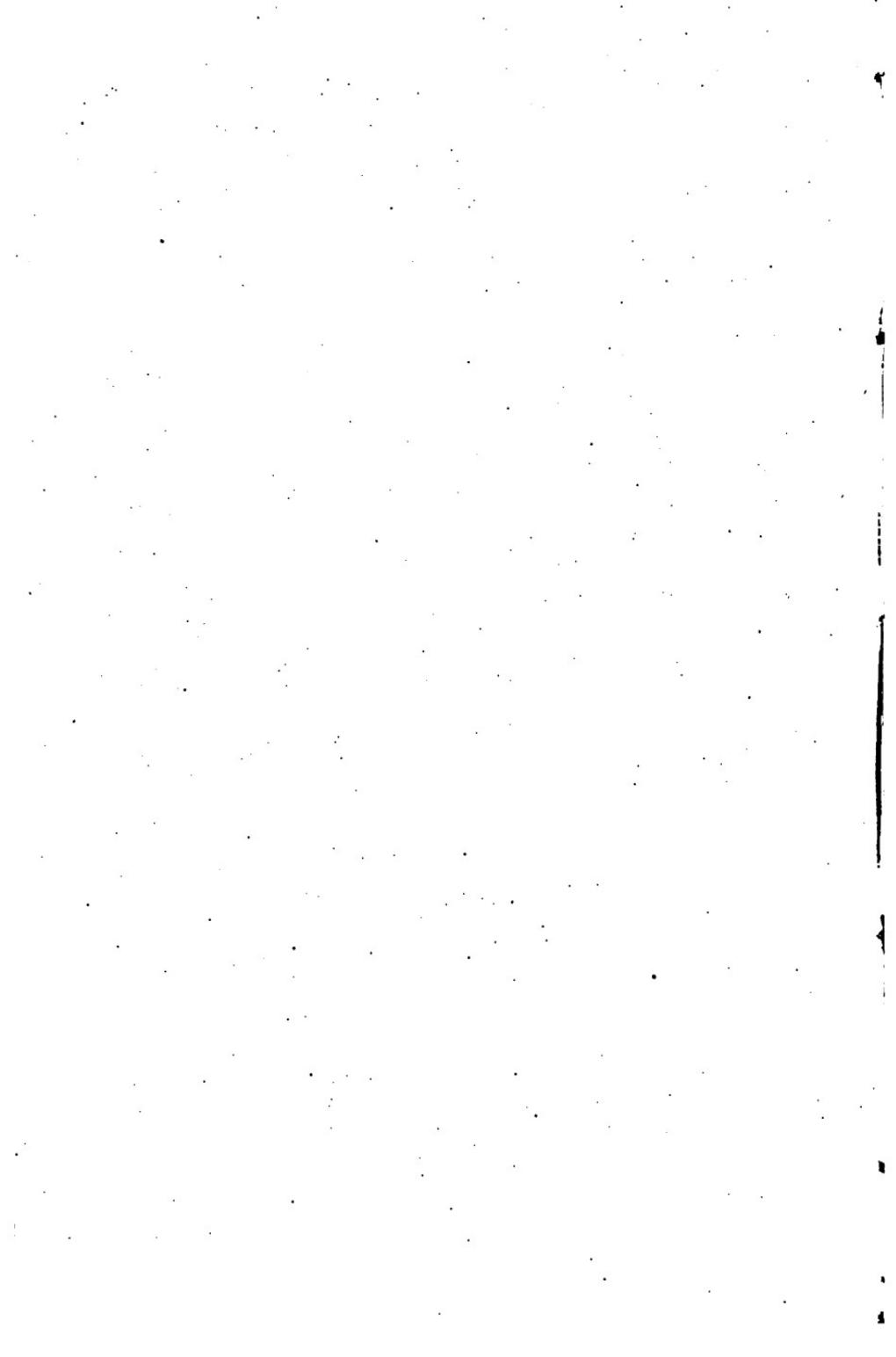
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**ALPHABETICAL MANUAL
OF
BLOWPIPE ANALYSIS.**

Ballantyne Press

BALLANTYNE, HANSON AND CO.
EDINBURGH AND LONDON

17212

ALPHABETICAL MANUAL OF BLOWPIPE ANALYSIS.

SHOWING ALL KNOWN METHODS
OLD AND NEW.

LIEUT.-COLONEL W. A. ROSS, LATE R.A.

MEMBER OF THE GERMAN CHEMICAL SOCIETY
(AUTHOR OF "PYROLOGY, OR FIRE CHEMISTRY").



"If scientific training is to yield its most eminent results, it must be made practical. Don't be satisfied with telling a student that a magnet attracts iron. Let him *feel the pull for himself*."—HUXLEY.

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1880:

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DEDICATION AND PREFACE.

TO PRINCE BISMARCK.

YOUR HIGHNESS.—In availing myself of Your Highness's gracious permission to inscribe to you these humble fruits of twenty years' study, I am anxious to show that such a daring ambition is not so utterly unworthy of its great object as it may seem to those who have not investigated the almost untrodden paths of this comparatively new science.

The Chemical Blowpipe is a legacy left to the wiser nations of Europe by the Swedes, whose work in the matter died with Berzelius at Stockholm in 1845. It is an instrument which with apparatus costs only a few shillings, and is therefore available to the humblest workman. Treated with the consideration due to its modest excellence, it teaches us the proportional combinations (or chemistry) of inorganic substances in fusion by a direct source of heat ; just as ordinary chemistry consists in a knowledge of the molecular proportions in which substances contained in water-solutions of acids or alkalies, or of both, combine to form other definite substances or salts.

In order to show Your Highness how little its value

has been appreciated by the English in one of the most important arts in England and Germany—an art whose legitimate development springs from the scientific application of the chemical principles elucidated properly by it alone—I would mention here that the most elaborate work on *Metallurgy* in the English language does not contain a single word with reference to the use of the blowpipe in that branch of chemistry, while, on the other hand, one of our most original and neglected metallurgists (Makins) says—

“For qualitative metallurgical examinations the blowpipe is *invaluable*, for by it we can command an immediate intense heat perfectly variable at pleasure as to the nature of its action and effects; and, moreover, can work with the greatest facility and certainty upon masses of material far too minute for any other kind of manipulation.”

I deeply regret to be obliged to add that there is not even the pretence of systematic tuition in this important branch of chemistry where one would most expect to find it, and students from London are therefore compelled to resort to Freiberg University.

As a philosophical instrument the blowpipe has shown us simple but satisfactory methods of ascertaining as much as the spectroscope in the most practised hands can, regarding the nature of the metallic “elements,” the so-called “sodium lines” of the solar spectrum, &c.; while, as the cheapest and most effective means of technically educating the great mass of a people by putting a reactionary power *into their own hands* instead of on lecture tables illuminated by electric lights, and burdened with expensive apparatus—it stands without a rival, and even without a second.

To Germany alone must be ascribed the credit and prescience of accepting the Swedish legacy, and the great names of *Plattner*, *Bunsen*, and *Fresenius*, are further evidence, were such required, that in this branch of science, as in most others up to the science of war, the Germans stand pre-eminent in Europe.

I cannot more appropriately conclude than in the words of the much-maligned historian of Florence :—

“ Those who court the favour of Princes generally present them with whatever they possess that is most rare, curious, or valuable. My anxiety, therefore, to present myself to the notice of Your Highness with the best proof of my devotion, has not enabled me to discover anything I esteem more, or account so valuable, as a knowledge of this science, and although I have not the vanity to deem it worthy of your acceptance, yet I am persuaded that your goodness will not refuse the offering. The observations which I have made with all the accuracy, reflection, and care of which I am capable, are contained in the small volume now addressed to you.

“ I am, therefore, bold enough to hope that you will accept this feeble tribute in reference to the intention with which it is offered, and if you condescend to read it with attention, you will have evidence of my ardent desire to see you fill for many years more those high destinies to which fortune and your splendid talents have called you.”

May I ask Your Highness to note the concluding sentence of the original which I do not venture to quote here, but hasten to subscribe myself

Your Highness's respectful admirer and

Most obedient Servant,

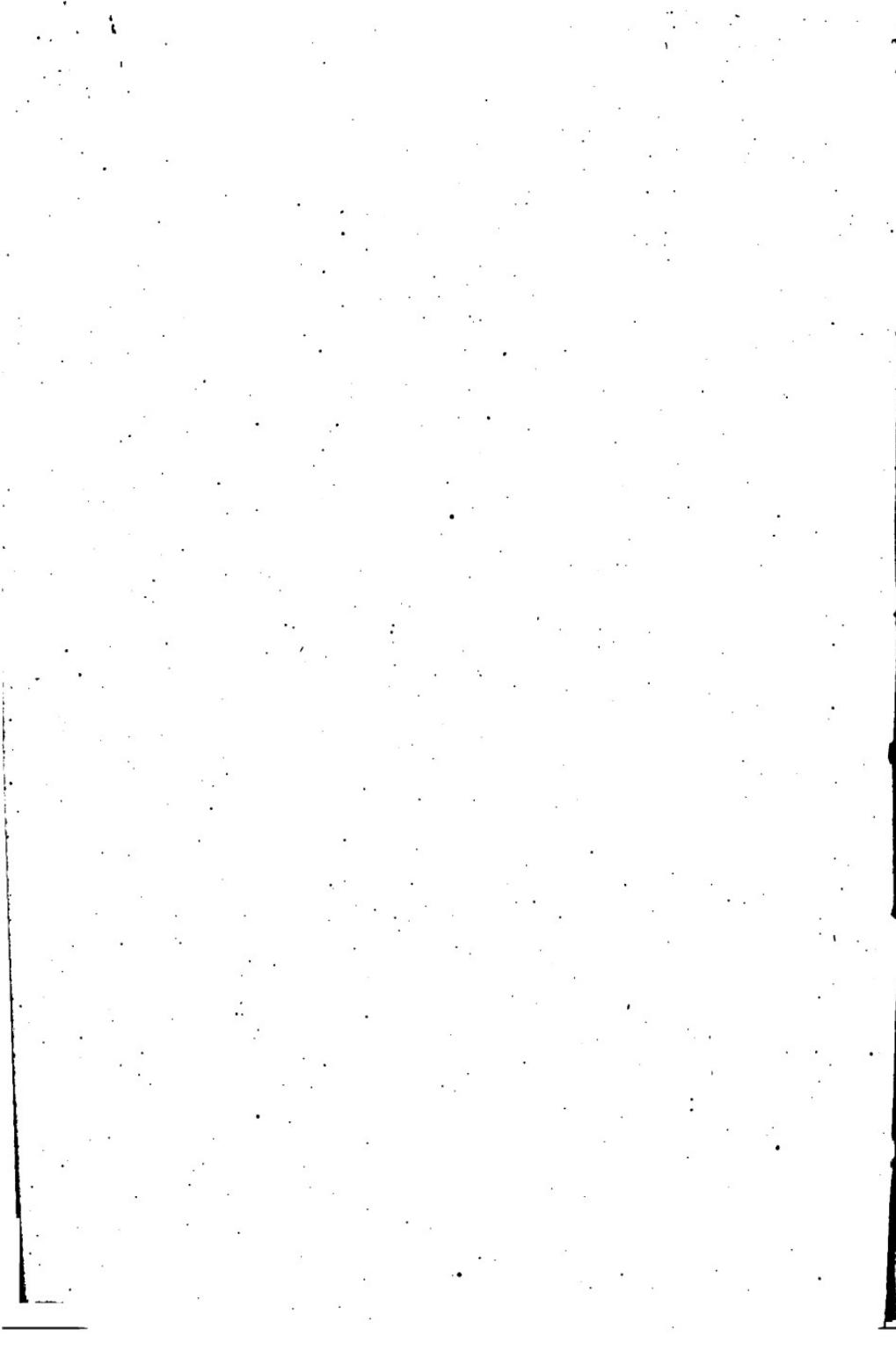
W. A. ROSS.

LONDON, W., 1st May 1880.



EXPLANATION OF TERMS AND SYMBOLS, &c.

Pyrocone	A flame having a conical shape.
Pyrochrome	A non-luminous flame tinged with colour: symbol, p.c.
H.P.	Hydrocarbonous pyrocone: old R.F.
O.P.	Oxyhydrogen pyrocone: old O.F.
P.P.	Peroxidising pyrocone: no old name.
E.P.	Ellychnine pyrochrome. (See that head.)
H.B.	Fused boric acid.
H.P.	Fused phosphoric acid.
A bead	The <i>largest</i> amount of flux fusible on a platinum ring of given diameter.
A glass	The <i>smallest</i> ditto.
H.S.	Hydrosulphuric acid.
Al.	Aluminium.
MnO₂	Manganese dioxide.
HCl.	Hydrochloric acid.
KHSO₄	Acid potassium sulphate.
H₂O.	Water.
Al₂O₃	Alumina.
Cr₂O₃	Chromium sesquioxide.
Cu₂O.	Copper suboxide.
SO₂	Sulphurous acid (sulphur fumes).
CoO.	Oxide of cobalt.



ALPHABETICAL MANUAL OF BLOWPIPE ANALYSIS.

GENERAL COURSE OF EXAMINATION.

(I.) LENS.

(A.) Metallic Lustre (tested on aluminium plate, and afterwards by boric or phosphoric acid) :—

- (a.) Native metals.
- (b.) Arsenides.
- (c.) Sulphides.

(B.) Vitreo-Metallic Lustre (tested by boric acid) :—

- (a.) As Mica.
- (b.) „ Talc.
- (c.) „ Graphite.

(C.) Vitreous Lustre (tested by boric acid) :—

- (a.) Quartz, transparent, opaque, or coloured.
- (b.) Diamond.
- (c.) Gems, as Emerald, Zircon, &c.
- (d.) Tourmaline.

(D.) Lustreless Substances (tested by boric or phosphoric acid) :—

- (a.) *White*, as Marble.
- (b.) *Coloured*, as Hematite.
- (c.) *Black*, as Anthraconite.

N.B.—The lens should also be used after every opera-

tion, and a note made of the appearance of the substance at that stage.

(2.) CLOSED GLASS TUBE.

(See BULBS, GLASS.)

(3.) ALUMINIUM PLATE.

(The Al. spoon may be used in some cases, as for pyrochrome.)

(A.) The substance, from a pin's-head size, is kept on the ledge just within the point of the blue pyrocone; if the blast moves it, to be fastened down by a speck of boric acid, and these facts noted:—

- (a.) A smell or not.
- (b.) A sublimate or not.
- (c.) A pyrochrome or not.

(B.) A drop of water is shaken on the hot substance, and these facts noted:—

- (a.) If the steam smells after H.P.
- (b.) If there is a stain on the Al. plate.
- (c.) If the Al. plate is corroded (chlorine).

(C.) A charcoal mortar is slipped under the substance, and the above observations repeated.

(D.) A ball of sodium carbonate is fused in O.P. on the bare Al. plate, and some of the powdered substance fused with it (detects sulphur, manganese, and some of the metallic oxides, as copper).

Potassium may be used instead of sodium carbonate, and any change in the violet pyrochrome noted.

(E.) Sublimates examined as directed.

(4.) BORIC ACID.

(A.) A fragment not larger than a pin's head, or some powder, is taken up at bottom of the red-hot bead and

treated with O.P., when these phenomena are to be noted :—

- (a.) Pyrochrome before combining with the boric acid.
- (b.) Do. after combination.
- (c.) Effervescence in combining.
- (d.) Smell.
- (e.) If balls—clear or opaque, coloured or colourless—are formed inside the bead.
- (f.) If the substance remains in fragments, and whether these are unaltered, or rounded on edges: whether colour is changed or assumed.
- (g.) Opalescence, which is to be determined as chemical water or phosphoric acid.

(B.) The bead is boiled in water and the insoluble contents examined on a blotting-pad through the lens; if transparent, in forceps through the spectroscope.

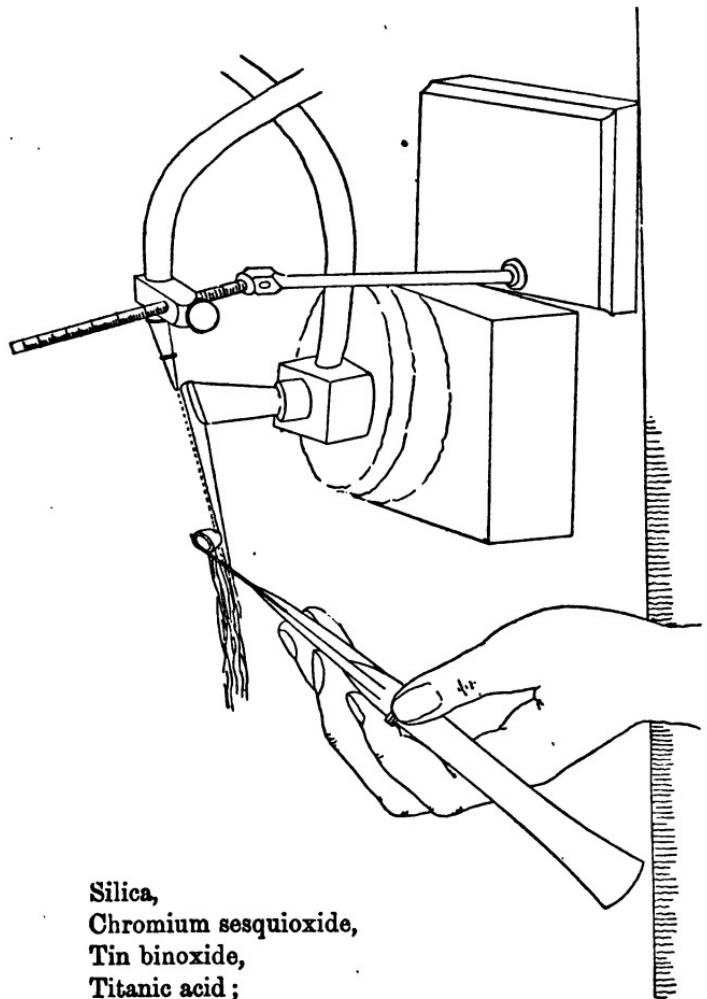
(C.) The bead is vesiculated, to detect minute particles or balls, metallic or otherwise; also the presence of traces of chlorine. (See the proper heads.)

(5.) PHOSPHORIC ACID.

(A.) A fragment not larger than a pin's head (and if that prove insoluble or unattackable, some of the powder) is taken up at bottom of the red-hot bead and treated with O.P. for a moment only, when these phenomena are to be noted :—

- (a.) Effervescence.
- (b.) Smell.
- (c.) If bubbles are coloured, as with oxide of manganese (crimson).
- (d.) If gelatinous, transparent matter exudes through the bead, which generally denotes a malleable metallic oxide.

(B.) The substance is now completely dissolved by strong O.P., the following being nearly insoluble :—



and the colour of the resulting bead, while hot and cold,

examined through the lens by reflected and transmitted light, and also with the spectroscope.

(C.) Vesiculation can be employed to determine minute particles of metallic or undissolved substances.

(6.) BORAX AND PHOSPHOR-SALT.

(A.) About 20 per cent. of sodium carbonate is added, B.B., to beads (4) and (5) respectively, until cobalt oxide in them remains blue cold, and reactions observed as in the combined table appended. Or sodium carbonate may be added in each individual case, after the reactions of (4) and (5) have been noted, where the reactions of these two salts are applicable; but to *begin* with either of these reagents, seems to me as absurd as a chemist commencing the solution of a substance in a test tube with sodium nitrate instead of with nitric acid.

(7.) COBALT SOLUTION.

(A.) A fragment which does not decrepitate or fuse held in platinum forceps, is heated in O.P. gently for some time, and a drop of cobalt solution shaken on it when cool, and any colour change noted.*

(a.) The fragment is again treated, this time strongly, in O.P., and fresh changes noted.†

(8.) TESTING FOR PYROCHROMES OR COLOURED FLAMES.

(A.) This is often observed in (3), when the substance

* This process is extremely useful in detecting *lime* or *strontia* in combination.

† This chiefly detects *alumina* or *magnesia*. (See SOLUTIONS.)

TABLE (I.) OF REACTIONS OF ORDINARY OXIDES AT ONE VIEW.

OXIDES OF THE - FOLLOWING METALS		Per Se. a Platinum Wire. b Aluminium Wire.		Cobalt Solution, a before O.P., b after O.P.	Boric Acid, a in O.P., b in H.P.	Phosphoric Acid, a in O.P., b in H.P.	Borax, a in O.P., b in H.P.	Micro Salt, a in O.P., b in H.P.	Sod. Carb. a on Al. Plate, b on Pt. Wire.
BEHAVE THUS, ON AND IN									
Aluminium	Black in H.P. (a)	Blue (b)	Bluish-green (b)	Boric Acid. a in O.P. b in H.P.	Stearic fragments at- tacking lime balls Icy mass	Str. garlic smell	*	*	Crystals (?) (a)
Antimony	W. Sublimate (?)	*	*		Brownish W. matter	*	**	**	
Arsenic	W. Sublimate (?)	*	*		Clear balls and opal. matter	*	*	*	
Barium	Green P.c. (a, b)	*	*		Rusty floc. matter	*	*	*	
Bismuth	Yel. Sublimate (b)	*	*		Clear ball	*	*	*	
Cadmium	Brown Sublimate (b)	*	*		Clear balls	*	*	*	
Calcium	Orange red P.c.	*	*		Brown balls	*	*	*	
Cerium	*	*	*						
Chromium	*	*	*		Green fragments	Yel. hot like iron	Yel. hot like iron	Yel. hot like iron	Yellow P.P. (b)
Cobalt	*	*	*		Black balls	Green; red, hot Blue	Green; red, hot Blue	Green; red, hot Blue	Metal (a)
Copper	Green P.c.	*	*		Black balls	Blue (b), green (b)	Green-blue	*	
Didymium	*	*	*		Pink ball	*	*	*	
Erbium	*	*	*		Fragments	*	*	*	
Glucinium	*	*	*		White fragments, not attacking lime balls	*	*	*	
Gold	Pink Sublimate (b)	*	*		Rusty balls	Violet (a), bluish dirty (b) Blood red (a)	*	*	Yellow (a), brown (b)
Iron	*	*	*		Bluish clear balls	Yellow (a), green (b)	*	*	Yellowish- brown H.P. (a)
Lanthanum	Brown Sublimate (?)	*	*		Creamy matter	*	*	*	
Lead	Carmine P.c. (a)	*	*		*	*	*	*	
Lithium	*	*	*						
Magnesium	*	*	*						
Manganese	White Sublimate (b)	*	*		White opaque balls Clear brown balls (a), colourless balls (b)	Turns cobalt ox- ide blue	*	*	Amethyst (a), colourless (b)
Mercury	Blue Sublimate H.P. (b)	*	*		Black fragments	Amethyst (a), colourless (b)	*	*	Amethyst (a), colourless (b)
Molybdenum						Blue with little Green with much			Turq.-blue op. P.P. (c)

* No useful reaction.
† Made by adding B.B. as much Soda to Boric or Phosphoric Acid as will turn the pink of Cobalt in them blue.

is fastened on the Al. spoon with a speck of boric acid, or in the case of the yellow flame given by nearly all silicates whether they contain sodium or not; in the boric acid bead itself, the pyrochrome of which is *yellowed* by soda and phosphoric acid only.

- (a.) But for testing the substance *per se*, the ordinary platinum tongs would perhaps be the best support, if, unfortunately, platinum over a certain thickness did not emit a strong yellow flame, B.B., which would obscure most faint pyrochromes.
- (b.) It is often, therefore, safer to hold the fragment in a thickish platinum wire, bent as in the accompanying sketch, and held in an ordinary pair of pliers.

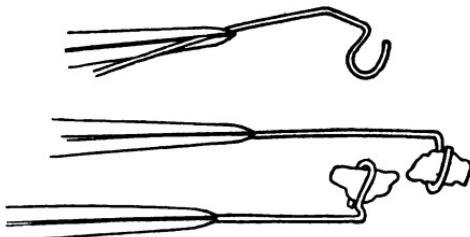


Fig. 2, 3, 4.

(9.) TESTING WITH ALKALIES.

(See SODA and POTASH.)

The above is a brief outline of operations which, carefully carried through, will give the examiner some idea of the character of most compounds; but in complicated cases

further research, as by "lead fuming," may have to be resorted to, details of which will be found under special heads.

ACIDS, to detect. (See special heads.)

AGATE SLABS. Two rectangular slabs 2 by 1.5 inches and 1 inch thick, polished on one side, smooth on all. These are cheap, and far more to be depended on than the more expensive mortars, which acquire, after silicates, &c., have been ground in them, interstices, in which fine powder lodges, contaminating fresh substances, while slabs, on the other hand, can be easily repolished.

They are used (a) for crushing small fragments of minerals, &c., with or without water; and (b) for supporting powdered substances, precipitates, and residues, &c., to be taken up by hot beads of boric or phosphoric acid.

(a.) After crushing the fragment of a mineral with the forceps (see (a) FORCEPS), one slab can be pressed upon the other with the coarse powder between, and finally, the upper agate is to be rubbed circularly over the under one—if a paste is required, with the addition of a drop of water—until a dust is obtained finer even than can be obtained by use of the mortar. For quantitative operations, these slabs should be kept in a *leather case*, without, of course, a lid, when the pressing above described can be carried out without loss of fragments.

(b.) Especially useful in examining small precipitates and residues from boiling water which would be lost on a filter, in boric acid.

ALKALIES, to detect. (1.) Apply the powdered assay to an HB bead, with cobalt borate balls in it. A *pinkish suffusion* shows an alkali. Soda in trifling proportion is betrayed by heating the assay on an HB glass, when the green pyrochrome of the latter is *oranged*. As nearly all silicates, whether containing soda or not, give a "yellow flame" *per se*, this test, although obtained with the spectroscope, is not to be depended on, unless it acts as above on the boric acid pyrochrome.

(2.) *Potash* is detected in trifling proportion in presence even of lithia, as in *Lepidolite*, or of soda, by dissolving some of the powdered substance B.B. in phosphoric acid, which has a brownish-orange pyrochrome in P.P., when a trace of potash causes a temporary but distinct *violet tinge* to appear.

(3.) *Lithia* is detected in the smallest proportion by treating a fragment of the heated mineral or salt in a candle E.P.

(4.) Alkalies afford a *white* sublimate on Al. plate, which is *soluble in water*. (See ELLYCHNINE PYROCONE and special heads.)

ALKALIES as reagents. (See POTASSIUM and SODIUM CARBONATES.)

ALKALIMETER, COBALTINE. (See COBALT.)

ALKALINE EARTHS. (See CALCIUM, &c.)

ALLOYS, to detect. (1.) Place a piece the size of a large pin's head on Al. plate or spoon, and heat one side of the ball formed gently with a long P.P., but never sufficiently to cause fusion, as the ball in that case spins round and the metals are mixed again. *The metal having most attraction for heat will be found on that side;* the one

with least, at the back : generally distinguishable by colour. In most cases, the easiest oxidised metal is found nearest the source of heat. Thus, in case of an ordinary bronze pin, copper will be found at the back ; tin (oxidised) next the pyrocone.

(2.) The composition of some alloys is rapidly indicated by the *combined colour* they afford to a glass of H.P. Thus, German silver gives a green colour in O.P. from the blue of copper and the orange of nickel, afforded to that reagent. Following is a list of better known alloys :—

I.—Antimony (1), Copper (2), Tin (3).

Britannia Metal—(1) 16.51 per cent. ; (2) 1.85 per cent. ;
(3) 81.64 per cent.

Metal d'Alger—(1) trace ; (2) 5.00 ; (3) 95.00.

Socket Metal—(1) 44.45 ; (2) 22.22 ; (3) 33.33.

II.—Antimony (1), Copper (2), Lead (3).

Reflector Metal—(1) 8.60 ; (2) 82.18 ; (3) 9.22.

III.—Antimony (1), Copper (2), Tin (3), Zinc (4).

Britannia Metal—(1) 9.7 ; (2) 0.30 ; (3) 89.70 ; (4) 0.30.

IV.—Antimony (1), Bismuth (2), Copper (3), Tin (4).

Pewter—(1) 6.77 ; (2) 1.72 ; (3) 6.77 ; (4) 84.74.

Britannia Metal—(1) 7.14 ; (2) 1.78 ; (3) 1.78 ; (4) 89.30.

V.—Antimony (1), Tin (2).

Britannia Metal—(1) 10.00 ; (2) 90.00.

VI.—Antimony (1), Lead (2).

Type-founders' Metal—(1) 90.09 ; (2) 9.91.

 " " (1) 80.00 ; (2) 20.00.

VII.—Antimony (1), Bismuth (2), Lead (3), Tin (4).

Queen's Metal—(1) 8.33 ; (2) 8.34 ; (3) 8.33 ; (4) 75.00.

Perrotine-block Metal—(1) 10.50 ; (2) 9.00 ; (3) 32.5 ; (4) 48.00.

VIII.—Bismuth (1), Copper (2), Tin (3).

Table-bell Metal—(1) 0.63 ; (2) 2.06 ; (3) 97.31.

IX.—Bismuth (1), Mercury (2).

Amalgam for Spherical Mirrors—(1) 80.00 ; (2) 20.00.

X.—Bismuth (1), Lead (2), Tin (3).

Newton's Fusible Metal—(1) 50.00 ; (2) 29.97 ; (3) 20.03.

Rose's Fusible Metal—(1) 50.00; (2) 25.00; (3) 25.00.

Bismuth Solder—(1) 33.34; (2) 33.33; (3) 33.33.

Calico-printing Blocks—(1) 16.66; (2) 33.34; (3) 50.00.

XI.—Bismuth (1), Lead (2), Mercury (3), Tin (4).

Sph. Mirror Alal.—(1) 8.33; (2) 8.34; (3) 75.00; (4) 8.33.

Anatom. Inject. Metal—(1) 27.81; (2) 9.27; (3) 46.51; (4) 16.41.

XII.—Copper (1), Tin (2).

Bell Metal—(1) 80.00; (2) 20.00.

“ ” 60.00; (2) 40.00.

Gun Metal—(1) 90.90; (2) 9.10.

Chinese Gong—(1) 78.00; (2) 22.00.

Clock Bell—(1) 75.19; (2) 24.81.

Locomotive Axle Sockets—(1) 86.03; (2) 13.97.

Medal Bronze—(1) 92.00; (2) 8.00.

XIII.—Copper (1), Zinc (2).

Brass—(1) 70.00; (2) 30.00 (average).

Pinchbeck—(1) 85.00; (2) 15.00.

Imitation Gold—(1) 82.85; (2) 17.15.

Mosaic Gold—(1) 64.51; (2) 35.49.

Brass Solder—(1) 45.00; (2) 55.00.

XIV.—Copper (1), Silver (2).

English Coin—(1) 7.50; (2) 92.50.

French “ ” (1) 10.00; (2) 90.00.

American “ ” (1) “ ” (2) “ ”

XV.—Copper (1), Gold (2).

English Red Gold—(1) 66.67; (2) 33.33.

XVI.—Copper (1), Mercury (2).

Dentists' Cu. Alal.—(1) 30.00; (2) 70.00.

XVII.—Copper (1), Tin (2), Zinc (3).

Manheim Gold—(1) 79.13; (2) 13.04; (3) 7.83.

Button Metal—(1) 62.22; (2) 2.78; (3) 35.00.

Metal "Stuffing-boxes" Loc.—(1) 90.06; (2) 3.56; (3) 6.38.

“ ” *Axle-tree Sockets*—(1) 82.00; (2) 10.00; (3) 8.00.

Bronze for Statues—(1) 84.42; (2) 4.30; (3) 11.28.

XVIII.—Copper (1), Lead (2), Zinc (3).

Alloy for Electro-plating—(1) 68.20; (2) 0.20; (3) 31.60.

XIX.—Copper (1), Silver (2), Zinc (3).

Silver Solder—(1) 14.75; (2) 77.05; (3) 8.20.

XX.—Copper (1), Gold (2), Silver (3).

Gold Solder—(1) 24.24; (2) 48.19; (3) 27.57.

Enamel Solder—(1) 25.00; (2) 67.93; (3) 7.07.

English "Fine Gold"—(1) 12.50; (2) 50.00; (3) 37.50.

, , *Coin*—(1) (3) 8.34; (2) 91.66.

French Coin—(1) (3) 10.00; (2) 90.00.

American , , "

XXI.—Copper (1), Nickel (2), Zinc (3).

German Silver—(1) 40.62; (2) 15.62; (3) 43.76.

Alfenide—(1) 59.60; (2) 10.10; (3) 30.30 (trace of iron).

XXII.—Copper (1), Arsenic (2), Tin (3).

Reflector Metal—(1) 66.22; (2) 0.67; (3) 33.11.

XXIII.—Copper (1), Lead (2), Tin (3), Zinc (4).

Gilt Wares—(1) 78.47; (2) 1.43; (3) 2.87; (4) 17.23.

Statue Bronze—(1) 78.50; (2) 1.40; (3) 2.90; (4) 17.20.

Bell Metal, Thomson's—(1) 80.00; (2) 4.30; (3) 10.10; (4) 5.60.

XXIV.—Copper (1), Gold (2), Silver (3), Zinc (4).

Gold Solder—(1) 26.25; (2) 36.25; (3) 31.25; (4) 6.25.

XXV.—Copper (1), Iron (2), Tin (3), Zinc (4).

Socket Metal (Locomotives, Belgian)—(1) 89.02; (2) 0.78;
(3) 2.44; (4) 7.76.

Socket Metal (Locomotives, English)—(1) 73.96; (2) 0.43;
(3) 9.49; (4) 9.03.

XXVI.—Copper (1), Arsenic (2), Platinum (3), Tin (4), Zinc (5).

Cooper's Reflector Metal—(1) 57.86; (2) 1.65; (3) 9.91; (4)
27.28; (5) 3.30.

(See special heads for detection of separate metals.)

ALUMINIUM PLATE, to use.* A rectangular strip of plate or foil, *not less than 4 by 2 inches*, of the thickness of this line (—), half an inch of the lower end of which should be turned up while the plate is hot on a table at an angle of 80°, as a lip or rest for the assay. One side may be graduated to show the comparative height of ascension

* Chlorides, or phosphates with a metallic base as *Libethinite*, should not be treated on these plates bare.

of sublimes. "The only charcoal required is a stock of small pieces about half an inch square, in which a hole, the shape of a key-hole, is made with a penknife (*vide MORTARS, KEYHOLE*) ; these slabs or lozenges are rather thicker than a penny piece, can easily be cut ready, and if required, carried in large numbers. A fragment of the substance, about half the size of a small pea, or, if it decrepitate, a

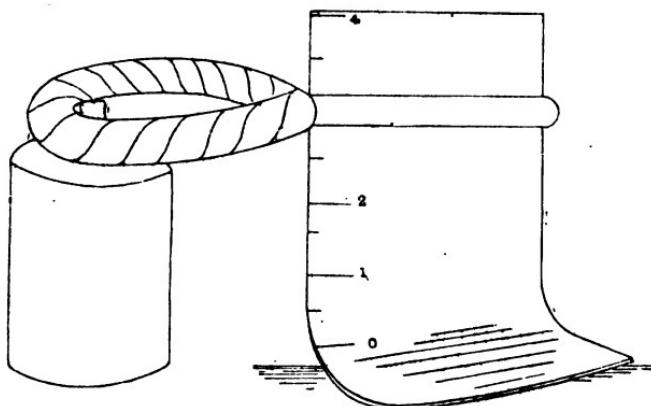


Fig. 5.

corresponding amount of powder made into paste, is laid upon the ledge close up to the angle, and heated very slightly, about half an inch from the tip of a pure blue flame. Any sublimate obtained should be examined from time to time, the heat being increased after each examination, till finally very little or nothing more is obtained, and only in cases where nothing is given off should it be brought so that the tip of the blue cone covers the assay, because some of the sublimes are so susceptible of reducing action, that if the flame were brought too close they would be altered before they could be observed."—H.

TABLE (II.) OF ALUMINIUM PLATE REACTIONS WITH CHARCOAL MORTAR.

Metal.	Strength of Sublimate.	Colours of Sublimate.	Reaction in P. P.	Sublimate in H.P.	Sublimate in H.B.
Antimony	30 Seconds O.P. Strong . . . = 2	Pale yellow ; higher, white Black ; higher, white	Unaltered Volatile	Instantly black Volatile	Icy mass Volatile
Arsenic	Very strong = 1	Yellow ; higher, orange and brown	Unaltered cold Unaltered cold	Dissolved colourless Dissolved colourless	Rusty streaks Clear ball
Bismuth	Moderate = 3 = 2	Reddish brown ; higher, dark brown	Unaltered cold Unaltered cold	Unaltered cold Blackened	Reduced to metal
Cadmium	Very weak = 5	Violet ; higher, pink	Unaltered cold	Almost black	Dissolved colourless See ANTI- MONY.
Gold	Lead = 3	Pale yellow ; higher, red orange	Dark brown	A splendid blue Velvety brown White	Reduced to metal
Pb. + Sb. . . . .	. . . . . = 3	Coffee brown ; yellow ; higher, orange	Yellow hot	Black in sol. fragments	Dissolved colourless See ANTI- MONY.
Molybdenum . . . . .	. . . . . = 2	Pale yellow ; higher, white	Red part whit- ened	Creamy streaks ; bluish	Black metal- lic lustre Slightly darkened
Selenium . . . . .	. . . . . = 1	Copper red ; white	Dark brown	Fragments insoluble Ball in mass	Unaltered
Silver	Weak = 4	White ; higher, brown and pink *	White ; turns reddish brown Unaltered	Like sago	.....
Thallium . . . . .	. . . . . = 2	Reddish brown ; higher, white	Black metal- lic lustre Slightly darkened	Fragments nearly insol.	.....
Tin	Scarcely any = 6	Yellowish white	Unaltered	Dissolved colourless	.....
Zinc . . . . .	. . . . . = 2	Black ; higher, white ; yellow hot.	Yellow hot	.....	.....

"If no sublimate is obtained either in the O.P. or in the blue tip, the powdered substance should be mixed with its own bulk, or rather more, of sodium carbonate, and the paste heated on charcoal slip within the blue tip. When a distinct sublimate has been obtained, the assay is removed from the plate, and further examination made as follows :—
1. The sublimate is held about $1\frac{1}{2}$ inches in front of a pure and moderately strong flame (P.P.), and the behaviour of its various portions noted. 2. The sublimate, after the application of P.P., is brought up so that the tip of the blue cone flattens against it on the plate, and the behaviour of the various portions again noted. Only a very pure flame is of any use for this, as the least streak of yellow in it causes instantly a sooty mark, which might be mistaken for some of the reactions produced; though such sooty marks are distinguished by their instant disappearance in H.P. Where the pure metals themselves are used to produce sublimates, small pieces only should be taken, so that the size and appearance of the sublimate may be pretty much the same as would be obtained from a mineral containing a fair amount of the metal in question. The least amount of heat and blast should be employed which will suffice in each case to produce a distinct sublimate. Too much heat or too strong blowing causes the fumes to be unnecessarily spread out. The mouth blowpipe is best suited for this. The plate is cleaned with a bit of wash leather, and some fine-ground bone-ash and water. In many cases, just the wet leather is sufficient."—H. The plate is held in muffled forceps, such as those shown in figs. 5 and 27, to prevent the hand being burned; the steel part of which may be burnished, to show a very thin

coat of sublimation. I have just (January 1880) discovered that by far the best way to commence the examination of substances on Al. plate is to heat first in the end of the blue pyrocone (O.P.), so that, if they are fusible, they assume the globular shape, while the pyrochrome thus afforded shows in many cases the chief component. The ball or fragment is now submitted, first on the bare plate, then on C. slip, to a 2-inch P.P., so that only one side is heated to redness, and no fusion takes place, which would cause a *mélée* of constituents. The assay having cooled, is taken between forefinger and thumb, and carefully examined through a lens. It will be found that the most oxidisable substance (or metal in an alloy) now occupies that part which has been next the source of heat. A continued careful heat on this side only will often sublime the more volatile metal *per se* upon the plate; by which a process of separation, equal to that of "wet" analysis and far more rapid, may be achieved, for thus *every particle* of sublimate may be caught on the plate, and weighed there. Almost all sublimates, carefully scraped off with a penknife, mixed with three or four times its bulk of "reducing flux," and treated with O.P. in charcoal, may be reduced to a metallic ball or "button."

ALUMINIUM SPOON is made out of a piece of wire or rod about $\frac{1}{16}$ inch diameter, by hammering out the ends and punching small cavities in them. For pyrochromes, a fragment of the assay is fastened in a cavity by means of a crystal of boric acid, and heated only at top just within the tip of the blue. Large beads of soda and boric acid may also be heated on this support, but not of phosphoric acid, which produces after a time a

slight crust of aluminium phosphate. The held end of the spoon must be muffed with a strip of list or flannel.

ALUMINIUM CAPSULES AND SPATULA (figs. 6 and 7) are made like the Freiberg platinum spoons, but must have at least half-an-inch diameter. With water in them

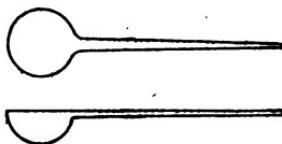


Fig. 6.

they stand the heat of the blowpipe pyrocone perfectly, and thus obviate the use of a spirit-lamp. A bead of boric

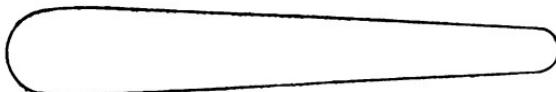


Fig. 7.

acid is boiled down in one, without stirring, in fifteen seconds; but they must never be heated without water.

ALUMINA, to detect. (1.) In the laboratory where it is pretty pure, and in minerals, such as *Cyanite*, where there is little association of metallic oxides, alumina is best determined by Gahn's method with cobalt solution. The fragment is first heated on Pt. wire or Al. spoon in a slight O.P.; then a drop of weak Co. solution added, and the colour noticed, as if it remains pink there is no *lime* or *strontia* present (see those heads). The whole is then heated strongly in O.P., when the aluminous part is found *bright blue*, which a large proportion of silica has a tendency to make purple. Fused silica affords a blue glass.

(2.) But for a trifling quantity of alumina in presence of other oxides the only safe test is to treat a trace of the substance in fine powder, on a large clear boric acid bead before O.P. for about a minute ; then add a pin's-head fragment of lime, and treat with O.P. again. If there is any alumina present, the resulting lime-borate ball will be *decomposed* and the whole bead become *milk-white* from the diffusion through it of uncombined lime, unless the alumina existed in the powder as phosphate, when the *clear* lime-borate ball will become *opaque-white* like a snowball (see PHOSPHORIC ACID). This delicate test may be made quantitative by previously weighing the lime-borate ball, because the loss of weight or decomposition is in proportion to the amount of alumina present (see SILICA).

(3.) A rough way of detecting alumina is by holding a pea fragment, supported on a platinum hook, in the flame of a spirit-lamp, or in a good blue candle H.P., when alumina and silica *blacken* ; the latter in crystalline facets, while lime and the alkaline earths remain white.

ALUSILCICEOUS MINERALS. (See ZEOLITIC SILICATES.)

ANALYSIS, QUALITATIVE. To compel the student to go through what is called "a systematic course of analysis" may be advisable in the case of an absolute beginner, but is only likely to irritate one more advanced, who has probably to search in the middle of the "course" for the reactions he requires.

Moreover, every two writers must have more or less different ideas as to what should be the proper *curriculum* of investigation ; and indeed all who have attempted it

already, seem to disagree like doctors. The only "course" of examination therefore given in this work, is that prefixed to it for the purpose of classifying minerals for treatment. (See **QUALITATIVE EXAMPLES**).

ANALYSIS, QUANTITATIVE. The only attempt hitherto made in this direction by the blowpipe has been by Harkort in the case of gold and silver, and consists essentially in a kind of minute cupellation. Plattner completed this idea, and extended it to other metals, but no one seems to have taken the obvious advantage afforded by the brilliant colours produced from many oxides in vitreous reagents by means of the blowpipe for this purpose. The processes treated of in this work are exclusively qualitative, but an example of quantitative treatment on the above plan has been given in the case of Cobalt, which seems to compare favourably with the arsenide process of Plattner. (See **COBALT**.)

ANTIMONY, to detect. (1.) Place the assay on a C. mortar on Al. plate. O.P. evolves a white sublimate, yellowish over black in the centre, which, when touched even by P.P., *turns dark*, but by O.P. *instantly black*. Lead sublimate turns brown thus treated, arsenic volatilises with garlic smell.

(2.) When uncombined with arsenic in a mineral, a very trifling proportion of Sb. can be detected by gently heating a pin's-head fragment at bottom of an HP bead in a momentary O.P., when a *smell of lucifer matches* is evolved and a curious icy appearance observed. The black antimonial sublimate gives a similar reaction. According to Hutchings—

(3). *Stibnite* and minerals containing antimony sulphide

give on Al. plate a dark yellow and yellowish-red sublimate of unoxidised sulphide, which oxidises on further exposure to the flame.

(4) "*Antimony with lead* is detected, even if present in very small amount, much more easily and certainly on aluminium than on charcoal in the ordinary way. By heating the antimonious lead on the bare plate, antimony sublimes practically free from lead, which can only with difficulty be made to afford any sublimate in such a position. If only a very trifling proportion of antimony be present, the assay is best placed with a fragment of boric acid half its size on the bare plate, and heated very strongly. Nothing at all will be obtained for some time, but as the temperature rises, a small pure white antimony sublimate slowly forms. The boric acid serves the double purpose of holding the little ball of lead down, and of taking up any oxide of lead which may be formed. It is in cases like this that the superiority of aluminium is most apparent; an amount of antimony that would be completely dissipated on ordinary charcoal, is here condensed into a small compact sublimate, and when so little is present as to give only a barely distinguishable film, it is proved to be antimony by its instant blackening in R.F."

(5.) "*Bournonite, Boulangerite, &c.*, treated on the bare ledge, give off almost all the antimony without any lead; afterwards on the charcoal slip, a sublimate of lead with little antimony; and finally, a pure lead sublimate can be obtained."—H.

(6.) An extremely small proportion of Sb. in a compound may be detected by burnishing one leg of the

iron forceps with the back of a table knife, and fastening it very high up the Al. plate which should then be inclined a little towards the O.P. : only Sb. sublimate can then rise as high as the forceps, and the faintest coat is detected by holding the polished leg slanting downwards towards a window (*Pyrol.*, p. 237).

(7.) In an HB glass the combined sublimate of Sb. and Pb. affords on cooling a *milk-white* OPAQUE glass ; the pure plumbic sublimate remaining perfectly clear (*Pyrol.*, p. 238).

(8.) According to Landauer (*Bl. Anal.*, p. 29), "most minerals yield antimony on the bare aluminium plate," but this is not my experience.

ANVIL MORTAR, commonly called "Abich's" (fig. 8).

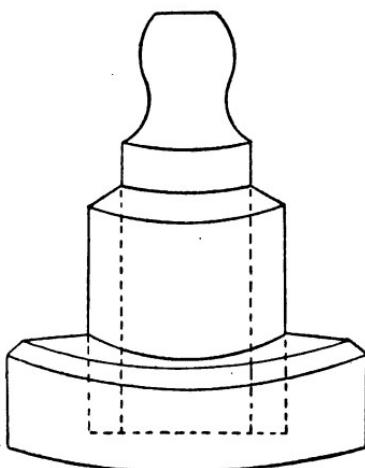


Fig. 8.

The one I use (fig. 9) is a rectangular prism of polished steel 2.5 inches long, the section of which forms a square of 1.5 inch. This is correctly bored longitudinally through the centre by a circle of .7 - inch diameter, into which exactly fits a piston of polished steel, divided into two or three parts, one of which serves as a bed or bottom ; and it

appears that an advantage is gained by hammering at both ends. *Corundum* can be instantaneously crushed to a fine powder in this mortar on a Brussels carpet. The powder

is obtained without any loss by pushing the piston through the cylinder on a piece of white paper, and carefully brushing the crushing end.

ARSENIC, to detect. (1.) Treat the assay as described under **ANTIMONY** (1), but note that, when touched with P.P. the sublimate vanishes.

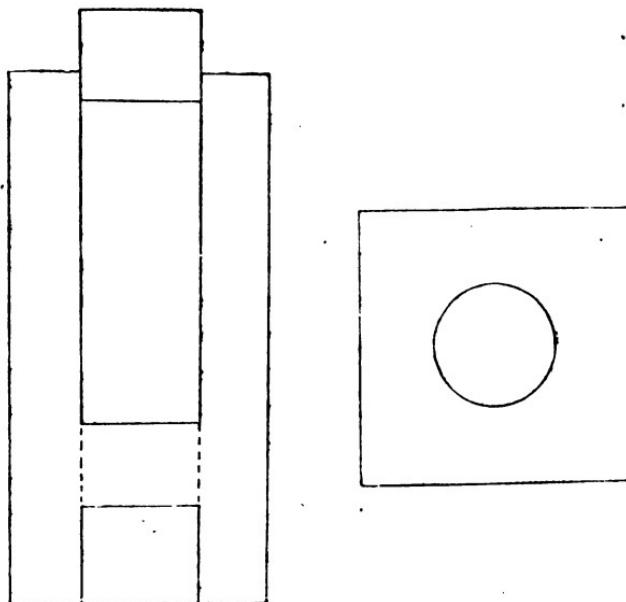


Fig. 9.

(2.) Treated at bottom of an H.B. bead in O.P., a *garlic smell* is evolved, and yellowish-white creamy matter is emitted in the bead, the best way of detecting traces of As. in organic tissues.

(3.) Arsenic may be detected when in too minute quantity to afford either a sublimate or smell *per se*, as in a fragment of the sand of *Jeypoorite*, by taking the particle

up at bottom of a largish bead of HP, treating the top of the bead momentarily with O.P., and smelling the "smoke" which arises as the bubbles burst.

(4.) "(Fragments of Niccolite or Smaltite are better for observing the sublimate on aluminium plate, than native arsenic.) When the quantity given off is not large, the sublimate is white, and there is a black stain under the assay when it is heated directly on the plate. When much As. is present and rapidly given off, there is also a good deal of grey-black sublimate, and there are large black stains on the ledge.

(5.) "In P.F. the white portion is unaltered, but volatilises rapidly as the plate gets hot. The grey-black and black portions are somewhat whitened and partly removed, but dark stains remain. In R.F. (blue tip) the white is not darkened, but volatilises rapidly. The arsenic smell is better noticed when substances are heated on the bare plate or on the small charcoal slip than on the ordinary large pieces of charcoal."—H.

(6.) According to Berzelius, a very minute quantity of arsenic trioxide can be easily detected by placing a fragment of the substance at the end of a drawn-out closed glass tube, such as pipette, and gently heated there with a splinter of charcoal. The As_2O_3 is reduced to metal as its vapour passes over the ignited charcoal, and a mirror is formed inside the glass above the heated portion of the tube.

BANDS, ABSORPTION, to obtain for the Spectroscope. The assay glass, except for didymium, which itself forms a clear ball in HB, is made of a calciboric ball about the size of a largish pin's head, extracted from its bead

according to the directions given under BORIC ACID. The ball is taken between the points of the (s) forceps, and held there by slipping up the wire band which keeps the legs together. The forceps, having the ball between its legs, is placed with its hilt inserted in the leaves of a thick book, placed on a table with the back towards the operator, so that the forceps stands upright, and the ball may be slanted towards or from him, as may transmit the greatest amount of light from a window, open, if possible, in front. (See TABLE I.)

The ball having been thus observed to afford a spectrum without bands, is now removed from the forceps, and treated in HB, so that a speck or two of the substance is taken up and dissolved in the *ball* (which rapidly thus attracts to itself most metallic oxides). The ball is then removed by boiling water and placed, as before, between the points of the forceps' legs, when, if the substance is one affording bands, they are at once seen through a spectroscope. The "purest" artificial oxide of cerium is thus proved to be never free from didymium. The chief of the rare substances thus examinable are didymium, erbium, and uranium (which see).

BARIUM, to detect. (1.) A pea fragment on Al. spoon or in Pt. forceps affords under O.P., unless the proportion of Ba. is very small, a *yellowish-green pyrochrome*, distinguished from that of boric acid by adding a trace of oxide of copper, which produces with the latter in O.P. an intense bluish-green.

(2.) Apply a pin's-head speck of the assay to HB if a *clear ball*, opaque while hot, is formed *at first* under O.P., but emitting a quantity of *thick opaline matter* into the

bead, the substance must contain a considerable proportion of baryta. Sulphates, however, as *Barite*, do not form balls in H_2O , while *Gypsum* and *Celestine* do, but are easily distinguished (see 1).

(3.) A speck or two of manganic dioxide added under O.P. in a bead of H_2O to a combined borate ball, will be coloured *red-brown* if baryta is present.

(4.) Add a drop of Mn. solution (sulphate will do) to a calcined fragment of the combination, and heat gently with O.P. Baryta, in absence of soda or potash, will cause a *yellowish-green* colour to appear.

BASINS, BOILING. These are invaluable little articles to the travelling pyrologist. The best size is 1-inch diameter, and as deep as possible. The Berlin made have a *blue cross* on the bottom. They are held over a spirit-lamp flame, or the *base* of a gas pyrocone, with the (*n*) forceps—which see.

BERYLLIUM. (See GLUCINUM.)

BISMUTH, to detect. (1.) Heat a pea fragment of the assay before O.P. on bare Al. plate for a second or two only. *Roundish metallic globules exude*; or, in mining phraseology, the mineral is said to “sweat.” This happens also, under similar conditions, to minerals containing tin, but in this case no sublimate is afforded by continued O.P. Bismuth is thus easily detected in *Rammelsbergite* containing, according to Plattner, only a trace of it.

(2.) Heat on charcoal over Al. plate the compound, with a mixture of equal parts of sulphur and iodide of potassium: the presence of Bi. is shown by a *volatile red coating* (Von Kobell).

(3.) Heat the assay strongly in O.P. on a C. mortar on Al. plate; if a *rusty-looking film* covers the steel forceps, becoming *gelatinous* when these are dipped in water, Bi. is certainly present.

(4.) In combination with lead or antimony, or with both, the assay is treated with P.P. in a C. mortar on Al. plate, a little of the sublimate gently scraped off with a penknife, and treated with H.P. in an HB bead on bare Al. plate, as Pt. wire is spoiled. *Yellowish-brown transparent streaks* are communicated to this opaque white glass by bismuth, which appearance is quite unique. The lead and antimony beads remain clear.

(5.) "Obtained from the charcoal slip, the sublimate of Bi., like that of lead, is yellow nearest the assay, passing into orange, and this into brown. The yellow is darker than with lead, and the yellow and orange are much more extensive than the brown (the reverse of what is obtained with lead); also this brown is not nearly so dark as that of lead, and has quite a different appearance. Outside of all and on the ledge of the Al. plate, is a good deal of pale yellow sublimate. In P.F. the yellow and orange darken in colour, but nothing like as much as the lead sublimate, and the greater part of the darkening *disappears on cooling*. This is a very characteristic difference between lead and bismuth. On charcoal in the ordinary way, the Pb. and Bi. sublimes are so much alike that they can hardly be distinguished. It will be seen that on Al. plate there are sufficient differences to render the distinction much more easy. If a little Bi. is suspected in a Pb. sublimate, a small quantity should be scraped off, and examined by the test with microcosmic salt and tin."—H.

(6.) Combined sublimate is dissolved in P. salt on Pt. wire in O.P., the bead struck off the wire, and reduced on charcoal with tin, when a grey or black colour indicates bismuth (Plattner).

BLOTTING PADS. An ordinary white one, cut into strips, is best.

BLOWPIPE, MOUTH. Gahn's form, with Plattner's

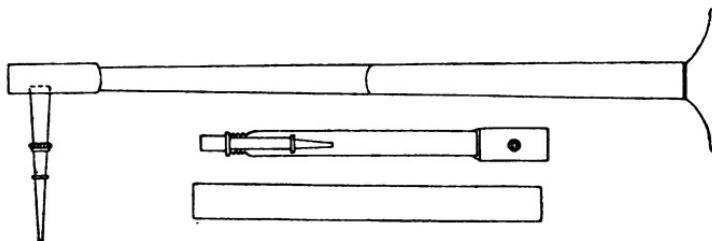


Fig. 10.

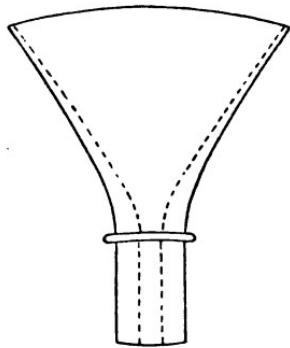


Fig. 11.

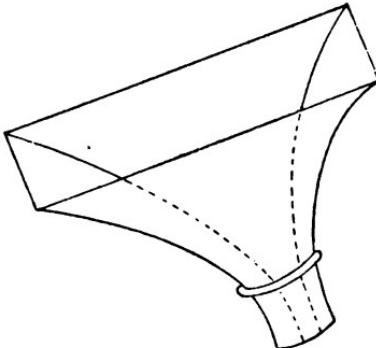
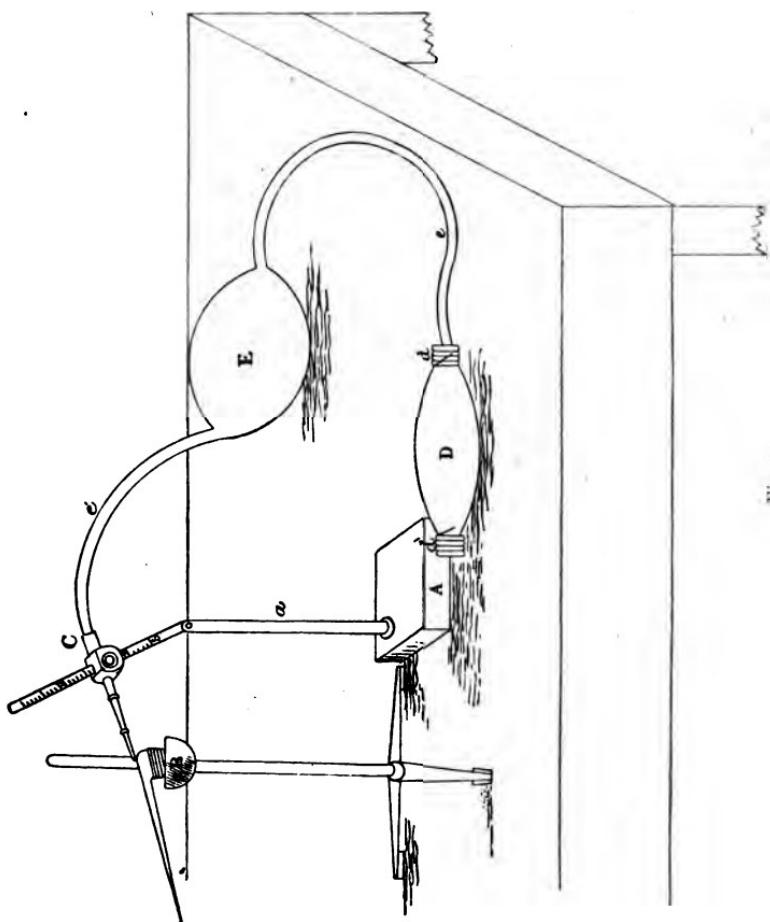


Fig. 12.

trumpet mouth-piece, is the best—indeed, the only efficient kind. Gutta-percha mouth-pieces pack well, as they can be flattened or opened by slight heating. The beginner should first try, with his mouth shut, to keep his cheeks

inflated for some time, and breathe the while strongly through his nostrils ; then he should allow a very little of



this air to escape through his nearly-closed lips, so that he feels it on the back of his hand, still breathing strongly

through the nostrils. With the cheeks thus inflated, he should now try to pronounce the word "cock," the effort to do which will at once replenish the breath in his cheeks by some fresh from the lungs.

BLOWPIPES, TABLE. One kind, used at Freiberg (fig. 13), consists of a vulcanised india-rubber bellows D, and air-reservoir E connected by an elastic tube (*ee'*) of the same material. At the end of this tube is a brass pipe C, on which fits a jet of platinum clamping upon an upright pillar Aa, having a joint in the centre by which the pipe is elevated or depressed. The upper half of this pillar may be graduated to show the angle of the blast (fig. 13).

Fletcher's Hand-Blower, with stand, is a far better apparatus. The bellows frame is made of wood, with stiff

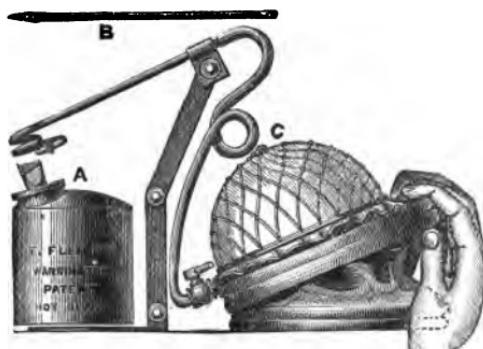


Fig. 14.

leather flap instead of vulcanised india-rubber, which soon becomes useless either in a very hot or very cold climate. The air reservoir is closely connected with this, instead of being detached, making it much more portable. The stand for the brass pipe carrying the platinum jet is especially

ingenious, for the candle or lamp itself serves as the weight to keep it up, thus enabling the traveller to put it, when folded up, in his waistcoat pocket. A brass tap is added to regulate the pressure of the blast, which can also be done by squeezing gently, instead of hard, with the right hand ; the left one holding the support with the assay. The figure (kindly lent to me by Mr. Fletcher) shows the bellows flat on the table, but I find it far more convenient to rest it edgewise.

Every operator should possess one or two of these cheap blowers, as, although it is quite possible to produce boric acid reactions with the mouth blowpipe, they require considerable practice, and nearly every other operation, with the exception of vesiculation, can be quite as well performed by means of a blower.

BOILING, MANIPULATION IN. It is often necessary to boil boric acid beads in water, in order to extract the contained balls, &c. In thus operating, the Berlin dish should always be held in the (n) pliers, and never placed on a stand or covered, because the progress of the operation must be watched, and not concealed. Spiriting can be prevented, either by using aluminium capsules, or by heating very gently. When the residue and solution appear distinct rest the dish on the table, drawing up the clasp wire which frees the pliers ; take up the dish in forefinger and thumb of the left hand, and gently tap it with the hilt of the pliers to determine fine precipitates, &c. Then decant the solution and draw off its last drops, by a slip of test blotting paper, blue or red, to determine if the solution is acid or alkaline. The precipitate should then be boiled in fresh water, at least once, and that

removed as before. A portion of the residue can then be taken out with the clean point of a penknife, and placed on the agate slab for examination. For balls or large fragments, the contents of the dish are thrown on a blotting pad (which see).

BORAX as a reagent. (See GENERAL COURSE OF EXAMINATION.)

BORERS, CHARCOAL. The best is the point of a penknife.

BORIC ACID as a reagent. Symbol, H_3B . It should form a perfectly transparent bead on platinum wire, with the evolution of few bubbles; but these should not be too easily expelled, as when pure it is a *viscid* flux. At the same time the pyrochrome should be observed, as if its pure green is *oranged*, it contains soda. A pin's-head speck of pure cobalt protoxide should, under O.P., form a *black ball* without the slightest *pink suffusion*, which denotes an alkaline adulteration. Under a good lens there should be *no specks* observable in the clear bead, whether needle-like and transparent (silica); white, opaque, and fat-like (alumina); or in the shape of balls (lime, iron, magnesia, &c.). Any *opacity* indicates free chemical water, which may even be derived from fusion in a platinum capsule. The slightest trace of phosphoric acid causes a boric acid bead to become opaline on cooling. The crystallised acid sold in most large druggists' shops is very generally pure, but takes a little longer to form a bead than the fused acid. Both kinds keep admirably in stoppered bottles anywhere. It is fused on the hot platinum wire like powdered borax, but, on account of its viscosity, takes a little longer to form a bead. With

the hand-blower, this is scarcely noticed. When most of the bubbles are expelled and a clear bead formed, some of the dry assay powder is taken up at bottom, and the following appearances noted :—

- (a.) Effervescence, or smell.
- (b.) Alteration of the green pyrochrome.
- (c.) Formations within the bead.

Appearance (a) denotes carbonates or sulphates by the bubbles of oxygen evolved on first heating them in the bead ; the smell detects fluorides or chlorides ; (b) is by far the most delicate detective of some substances, as *soda* and *copper* (see PYROCHROMES) ; (c) constitutes, from the great variety of forms exhibited, the chief value of this important reagent.

Oxides of the following metals form *balls* when applied B.B. to a bead of boric acid :—Barium, cadmium, calcium, cerium, cobalt, copper, didymium, iron, lanthanum, magnesium, manganese, strontium, zinc. As a rule, those metals which easily form carbonates form also borates in this way, but there are exceptions, as lead. For the different aspects of these basic borate balls, see the special heads.

To extract these balls, or other insoluble contents of a boric acid bead, it is thrown, wire and all, into an Al. capsule or Berlin basin of distilled water, and boiled. In the former, most beads are completely dissolved in 10 or 15 seconds. All balls are thus quite insoluble, but the clear ones sometimes break into fragments. For most purposes of qualitative analysis, it is sufficient to empty the capsule on a blotting pad, pick up balls or fragments with (n) pliers, and scrape precipitates off the blotting paper with a smooth-edged penknife.

Boric acid, like other beads, are best flattened for microscopic investigation by pressing either side while it is redhot against a smooth Al. plate. Either the "glass" thus formed, or the ordinary bead can be easily unrolled from the Pt. wire with the finger nail, but this will not do in quantitative analysis.

Boric acid beads are best for VESICULATION (which see).

The following letter appeared in the *Chemical News* of 9th November 1877. No notice to my knowledge has been taken of it :—

"SIR,—In a lately published work on chemistry, by Profs. Roscoe and Schorlemmer, under the head of 'Boron Trioxide,' the following passage occurs:—'Most metallic oxides dissolve in fused boron trioxide at a red heat, many of them imparting to the mass characteristic colours; hence this substance is much used in blowpipe analysis.'

"Now, this statement seems merely the repetition of a mistake, transferred from one book on chemistry to another, to which I have been attempting in vain to call scientific attention for the last eight years. It is particularly referred to at page 275 of my published work *Pyrology*, under the head of 'Cobalt,' the oxide of which supplies an excellent illustration in point.

"Most metallic oxides do *not* dissolve in boric acid before the blowpipe, do *not* impart colours to it, and finally it is *not* much used in blowpipe analysis, except for that made upon my system, which as regards boric acid is grounded upon the non-solubility of almost all metallic oxides, added to a bead of that reagent before the blowpipe. In short, what the chemists have written of the behaviour before the blowpipe of metallic oxides in 'boron trioxide' is true, not of it but of *borax*, a very different substance.

"I would appeal to any operator who has used boric acid in this manner for a confirmation (or contradiction) of these remarks.
—I am, &c.,

W. A. Ross."

BORIC ACID, to detect. (1.) Fuse a paste composed of some of the fine powdered mineral with $4\frac{1}{2}$ parts acid

potassium sulphate and 1 part pure fluor spar on platinum wire within the blue flame, which is then tinged transiently with a *yellowish-green coloration* (Turner).

(2.) Add phosphoric acid B.B. to a bead of boric acid until the opacity of the latter becomes *just* clarified and no more, so that the slightest addition of boric acid to the bead shall cause *opalescence* again to appear.

(3.) I have found the following plan of detecting boric acid in *Tourmaline*, &c., simpler and apparently as effective as (1) :—Fuse a bead of H_3P , and carefully note the colour given by holding it cold at the *top* of the *base* of a blue pyrocone, to the encircling vortex of heated air called “the mantle of the flame.” This colour, with pure phosphoric acid, will be found to be a pale apple-green, almost white. Now take upon the hot bead a paste made of the finely-powdered mineral and heated sulphur, and hold it cold in precisely the same position. A *yellowish-green mantle* will be distinctly observed, lasting for some time, especially if a black board or object be placed behind the pyrocone.

BOTTLES, oxide and specimen. German 2-inch bottles as thick as the little finger, are useful for keeping pattern oxides; specimen ones for keeping beads, &c., as small as can be procured. In both cases the symbol of the contents should be written on top of the cork. In the latter case the bottles may be filled with turpentine, which preserves the beads *in statu quo*, and any *weighed* contents written on the *side* of the cork, which is visible through the neck of the bottle.

BOTTLES, cobalt solution and dropping. These are of the ordinary kind (fig. 15), but a better kind is now

sold in which the solution is dropped from a hollow tube or pipette fitting down the centre of the bottle, by means of expansion of air caused by the heat of the hand. (*Dropping Bottle*, fig. 16.)

BROMINE, to detect. (1.) A little of the powdered assay is gently heated in a closed tube or bulb with twice as much acid potassium sulphate; a *reddish-brown vapour*

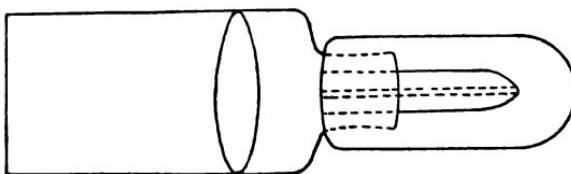


Fig. 15.

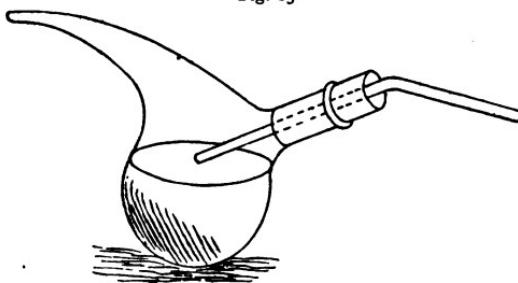


Fig. 16.

with the peculiar Br. smell which turns starch paste yellow appears.

(2.) Bromine has the effect of changing the green pyrochrome of copper to blue. (See CHLORINE.)

BRUSHES. Fig. 17 shows some useful kinds to have.

BULBS, GLASS. Small test tubes answer the purpose of these quite as well, and are in England much cheaper, besides being more easily cleaned.

The assay in powder is inserted in a tube about 2 inches long, the mouth stopped with the forefinger, and the under part held gradually over a spirit flame or the base of H.P., and the following phenomena noted:—(a.) Condensed drops—*water absorbed*, not chemical or constitutional; note if acid or alkaline, and slant the tube or

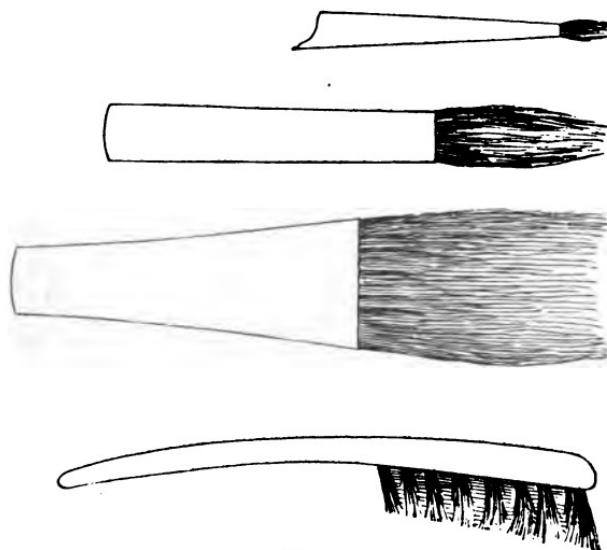


Fig. 17.

the water will flow back and crack the tube. (b.) Smell the mouth of the tube—*sulphurous acid*, pungent smell; *sulphuretted hydrogen*, smell of rotten eggs; *chlorine*, choking smell; *arsenic*, smell of garlic; *antimony*, with crystal of Hg , smell of lighted lucifer matches; *ammonia* with soda, well-known smell. (c.) Colour: *nitrous oxide* with copper filings, reddish-brown fumes; *nitric acid*, a slip of paper moistened with solution of ferrous sulphate inserted in the

neck of the bulb, turns *yellow or brown*; *chlorine*, greenish-yellow; *bromine*, brown; *iodine*, violet. (d.) A sublimate; better examined on aluminium plate without and then with charcoal slip. (See GENERAL COURSE OF EXAMINATION.)

CADMIUM, *to detect*. (1.) Treat the pea fragment on C. mortar on Al. plate. An *intensely brown sublimate*, unalterable by P.P. or H.P.

(2.) Chemically prepared cadmium brown oxide forms a *clear colourless ball* in HB, emitting a woolly matter into the bead, which is distinguished from that formed by zinc oxide by the former becoming reddish in H.P.

CALCIUM, *to detect lime in combination*. (1.) Heat a pea fragment in O.P. to redness, allow it to cool, and place a drop of cobalt solution on it. If it turns *blue*, lime or strontia is present; left a short time exposed, the limy fragment turns *green*, the strontia one *brown*.

(2.) Heat a splintery fragment in O.P., held by Pt. forceps till it glows; then touch the wick of a pyrological candle, from which a good blue pyrocone is being produced, with the calcined portion of the fragment; the surface of the blue pyrocone is momentarily dyed *red orange*.

(3.) Crush the fragment between agates, and heat a trace of the powder on an HB bead with O.P. *Balls appear*—(a) clear, colourless, hard-edged, not diffusing in the bead—*pure calcium, or strontium borates*; (b) opaque white, like snowballs—*calcium or strontium phosphoborates, or magnesium borates*. Distinguish strontia by (2) (see STRONTIUM), and magnesia by heating the balls with strong O.P. on the bead—if phosphoborates, they *cannot be*

clarified (see MAGNESIUM); (c) clear, yellowish-green balls—calcium or strontium borates *coloured by iron* (see IRON), which is always thus in the state of protoxide; (d) clear balls, covered by curious grammatic crystals—calcium or strontium borates, containing a very small proportion of *silicic acid* (see SILICA). To distinguish calcium phosphates see PHOSPHORIC ACID.

CANDLES, PYROLOGICAL, are of two kinds—(a) round, and (b) prismatic; *a* kind is an ordinary thick

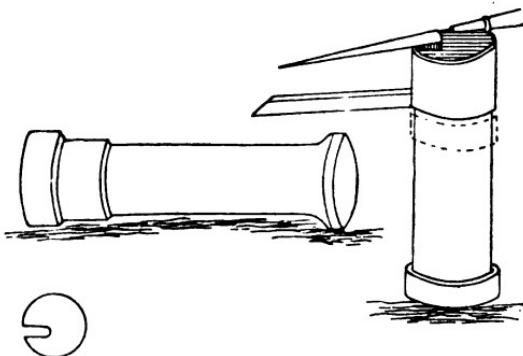


FIG. 18.

candle, but having its wick placed near the circumference, instead of being in the middle; *b* kind is a rectangular prism, conveniently made 3.7 inches long, 1.5 inch deep, and .7 inch thick, with the wick or wicks lying along one of the short sides. Round the end to be burned is slipped a zinc collar, about $\frac{2}{10}$ inch thick, which should fit neatly, but not too tight; another collar or ring may be used under the first, as shown in the figure, if found necessary. A solid socket covers the bottom, which, when either candle gets very low, is used as a lamp; only, the composition

in that case becoming fluid, the wicks should be retained in their place by a small piece of wire or zinc

foil. *c* in fig. 19 is a removable zinc tray, into which the candle ought to pack for convenience of carriage. Messrs. Price & Co., Battersea, make these candles, and Messrs. Griffin the stands for them. Fresh fuel can be supplied, as at *a*, fig. 19, by old candle ends, melted fat, or any solid hydro-carbon, but oil may be used in the socket. I tried to "Bunsenise" my candle, by sinking a brass tube perforated by lines of holes, into the composition round the wicks ; but this contrivance did not seem to alter the nature of the flame much.

CAPSULES. (1.) Fig. 20, natural size, of platinum, with

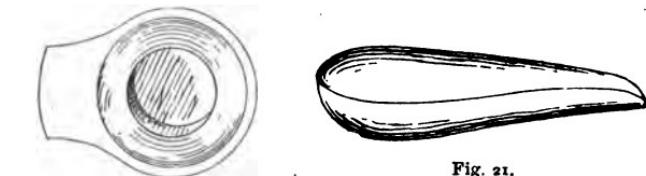


Fig. 20.

Fig. 21.

a flattened pistol bullet for keeping it down when acting as a cover for Berlin basins containing boiling solutions ;

and (2.) Aluminium Capsules, in size and shape like the smallest kind of the above-mentioned basins, are used by me (see AL. CAPSULES). Fig. 21 is a Freiberg horn or brass capsule for transferring powders or small particles to vessels with contracted mouths, as small bottles.

CARBONIC ACID, to detect. (1.) Carbonates effervesce in HB before the blowpipe, and are distinguished from sulphates, which also effervesce, by the fact that the former temporarily *orangise* the green pyrochrome, while the latter heighten its tint. The fragment is taken up at bottom of the hot bead on Pt. wire, and CO₂ may be thus rapidly as well as accurately determined quantitatively in the alkaline earths.

(2.) Plunge the hot HB bead, before the above-mentioned effervescence has ceased, into a small test tube containing lime water, which is then *made turbid* by carbonates only.

CERIUM, to detect. (1.) Calcine the powdered assay slightly through Al. plate, then treat some of the powder on an HB bead with O.P. *Nut-brown transparent balls* appear, which might be due to manganese, but

(2.) Boil the bead in an Al. capsule, extract the balls by emptying it on a blotting pad, and examine with a spectroscope (see SPECTROSCOPE). *Thick black lines*, like the steps of a ladder, *appear* in D. and Eb. of the spectrum. These are due to the presence of didymium, which has never yet been completely separated from cerium. (See DIDYMIUM and LANTHANUM).

CHARCOAL. (See ALUMINIUM PLATE and MORTARS, KEYHOLE.)

CHEMICAL WATER. A combustible, but not vapor-

sible compound, composed apparently of hydrogen and oxygen; present in every natural, and in almost every artificially prepared oxide. It ignites at apparently red heat, and burns with an *orange* pyrochrome. *To detect it.* (1.) Treat a speck of the powder on an HB bead in O.P.; *opalescence intervenes* on cooling, as for instance in pure calcium hydrate, the clear lime-borate ball being found by the balance to be composed of the whole of the lime present; the opalescence, therefore, must be due to the chemical water.

(2.) Let the yellow or D line producing "flame" from clean new platinum foil treated in O.P., impinge on a bead of boric acid; the bead soon *becomes opalescent*; now let the D line producing "flame" from any sodium salt impinge in like manner on the same bead. The *opalescence is removed*. (Disting. from Na.)

CHLORINE, *to detect*. (1.) Make a small bead of phosphoric or boric acid on the loop of a copper wire, and treat a trace of the powdered assay in H.P. The green pyrochrome is *changed to an intense sky-blue* if chlorine is present (Berzelius).

(2.) If the assay contain lime, treat a paste on Pt. wire in a candle H.P.; if not, add lime free from chlorine to it. *A black spot*, round in proportion to the roundness of the mass which does not blacken all over, *appears next the pyrocone*. This spot has a sweet taste, and may consist of carbon chloride.

(3.) Dissolve a large trace of the finely-powdered assay in a blue-green bead of HP, made by adding about 5 per cent. of copper oxide in a P.P. The blue-green bead now remains *olive-green* after P.P. on cooling.

(4.) The assay fused in a bead of H_2B under O.P. emits a strong *chloric smell* if Cl. is present to any extent.

CHROMIUM, *to detect.* (1.) Treat a trace of the finely-powdered assay on a bead of H_2B in O.P. *Insoluble green fragments appear.* If the bead is rendered opaque by diffusion of water from hydrates or other cause, boil it in an Al. capsule, and treat all contents in a fresh bead. Should the green fragments be taken up by a ball-forming oxide and thus concealed, treat some of the assay paste with a little proof lead in a C. mortar on Al. plate. Scrape off some of the resulting sublimate with a penknife and treat as before in H_2B ; Cr. is at once detected in the shape of *insoluble green fragments*.

(2.) Nickel oxide also forms green fragments in H_2B . Distinguish by adding soda and dissolving all contents in O.P. The chromium bead is *green*, the nickel one brown.

(3.) To distinguish from the green bead also formed by uranium oxide, apply the spectroscope to the transmitted light. The chromium spectrum has *no absorption bands*. The chromium bead is also distinctly *red while hot*, a phenomenon observable in no other green bead.

COAL-GAS as fuel. Must not be used in the detection of sulphur compounds.

COBALT, *to detect.* Apply a few specks of the powdered substance, which from its appearance will probably have been previously roasted on Al. plate (see GENERAL COURSE OF EXAMINATION), to a bead of H_2B under O.P.; *small black balls* are discovered floating in the clear bead which, after H.B., become violet. These may be—(a) Borates of ferric sesquioxide; (b) of copper protoxide; (c) of cobalt monoxide; or of all three, which,

by boiling the bead in an Al capsule, &c., may be separated for individual examination. (See special heads.) Apply B.B., a speck of potassium carbonate—sodium would obliterate the blue-green pyrochrome which betrays the presence of copper—to the part of the bead nearest the balls, and treat both with a gentle O.P. A clear pinkish suffusion is found over the balls on cooling, caused only by cobalt, and if the other balls can be sacrificed, a little more alkali makes the whole bead *blue hot*, and *violet cold*: the same colours are afforded by the application of a trace of any substance containing cobalt to a bead of $\ddot{\text{H}}\text{P}$, in which the reactions of all other oxides are overpowered by it. Alloys, as for instance argentine, or metals, as commercial nickel, are best tested for cobalt in $\ddot{\text{H}}\text{P}$.

Cobalt ores generally, if not invariably, contain arsenic, and retain a proportion of that so tenaciously, that in some cases—e.g., that of the mineral *Jeypoorite*, examined by such a sagacious analyst as Middleton of the Royal School of Mines, who determined it a pure sulphide of cobalt (see *Philosophical Magazine*, III. xviii. 352)—the arsenic escapes detection. When an assay is so very small as a *Jeypoorite* crystal, it should be tested with a momentary O.P. at the bottom of a bead of $\ddot{\text{H}}\text{P}$ (see GENL. COURSE OF EXAM.—PHOS. ACID), which attacks most bases with equal violence and rapidity, liberating volatile constituents, which, if odoriferous, are at once recognised by their smell. (See ARSENIC and ANTIMONY, &c.)

A new method, devised by myself, of the blowpipe estimation of cobalt, is given here as an illustration, although properly belonging to quantitative analysis.

BLOWPIPE ASSAY OF ORES, FURNACE PRODUCTS, &c.,
FOR COBALT.

1. The *rationale* of this process depends upon the observations, (a) that a trace (say .5 mgr.) of cobalt oxide affords, when dissolved in a bead of microcosmic salt, *the same* colour (violetish-blue) which is afforded by the addition to a similar bead of *five times* as much oxide, or 2.5 mgrs.; and (b) that these relative quantities of cobalt oxide afford, when dissolved in *phosphoric acid* beads of the same weight (say 60 mgrs.), *perfectly different* colours; viz., *pink* as regards the smaller proportion, *violet* as regards the greater.

2. The corollary derivable from these premises seemed to me, therefore, that the quantity of phosphoric acid being kept constant, it would require the addition of more soda to turn the pink bead than the violet bead *blue*; first, because violet already contains blue; and second, because the cobalt might be presumed to have already saturated, as a chemical base, part of the phosphoric acid.

3. I was *exactly wrong* in this assumption. Different quantities of soda were, indeed, required to azurise the two beads, but the *violet* bead required *more* than the pink one.

4. Without troubling the reader with tedious details, I may state here that each of three assays constantly showed the necessity of an addition of 14 mgrs. of fused sodium carbonate in order to azurise a 60-mgrs. bead of phosphoric acid, made pink by the solution in it of .5 mgr. of pure cobalt oxide; and (by three other assays) an addition of 20 mgrs. of soda to azurise a 60-mgrs. bead made violet

by 3.5 mgrs. of cobalt oxide. The ratio, therefore, stood thus :—

$$\begin{array}{cccc} \text{NaO} & \text{NaO} & \text{CoO} & \text{CoO} \\ 20 & : & 14 & :: 3.5 & : .5 \end{array}$$

or, the violet standard of cobalt was to the pink standard as 2.45 : 0.71. It would seem, by these assays, that every half-milligramme between those extremes of cobalt oxide dissolved requires the addition to the bead of one milligramme of fused sodium carbonate, in order to azurise a 60-mgrs. bead of pure phosphoric acid.

5. The way to operate is to compare, by reflected and transmitted light, the blue colour thus obtained with that of two 60-mgrs. beads of *microcosmic salt*, having the above-named quantities of pure cobalt oxide respectively dissolved in them. Space does not allow me here to describe the *mechanical details* of operations which must be conducted with the utmost care.

6. From these facts, the following analytical table as regards *cobalt* is deduced :—

CoO mgrs.	NaCo ₃ mgrs.					
0.5	requires 14 = 0.83	{ per cent. of a 60-mgrs. phosphoric acid bead.				
1.0	,, 15 = 1.6	„	„	„	„	„
1.5	,, 16 = 2.5	„	„	„	„	„
2.0	,, 17 = 3.3	„	„	„	„	„
2.5	,, 18 = 4.1	„	„	„	„	„
3.0	,, 19 = 5.0	„	„	„	„	„
3.5	,, 20 = 5.8	„	„	„	„	„

The use of this table is shown in the following example :—

7. Assay (for Cobalt only) of Smalline from a Freiberg Cabinet.

		Mgrs.	Per cent.
(a)	Weight of powdered ore crushed between agates	= 50	—
(b)	Weight of powdered ore after roasting on aluminium plate	= 18	36
	Therefore the loss in arsenic and volatile constituents	= 32	64
(γ)	Weight of a new platinum wire with a ring of 1 diameter *	= 71.5	—
(δ)	Weight of the same platinum wire with a bead of phosphoric acid fused on it	= 134.5	—
(ε)	Weight of the bead and wire after 2.5 mgrs. of (β) had been dissolved in the former	= 124.0	—
(f)	Weight of the bead and wire after the addition of fresh phosphoric acid †	= 132.5	—

(This bead being *rose* colour,‡ *fused sodium carbonate* was cautiously taken up from an agate slab, and dissolved in it under O.P.)

	Mgrs.	Per cent.
(η)	Weight of soda required to colour to the <i>blue</i> of mic. salt with 2.5 CoO	= 16.5 —

Now, by the above table (6), 16.5 mgrs. of *soda* correspond to 3 per cent. of a 60-mgrs. bead in *pure* CoO; and 2.5 mgrs. of *pure* CoO, requiring 18 mgrs. of *soda*, constitute 4.1 per cent. of the bead. Therefore, we have the ratio—

$$4.1 : 3 :: 100 = \frac{4.1}{3} \text{ths of } 100 = 75 \text{ per cent.}$$

But, as this is the percentage of the *roasted powder*, or "regulus," we have—

Regulus in 100 mgrs.	Percentage of Regulus. Mgrs.	Mgrs. of Ore.
36	: 75	:: 100 = 20.08 per cent. cobalt.

* This refers to the "ringing forceps."

† This is necessary to make up the weight of the bead to 60 mgrs. After the addition of soda, there is no loss from volatilisation.

‡ From the interference of iron and nickel oxides in the assay.

Several assays were made with a similar result, but one other example is given here, with a different platinum wire :—

	Mgrs.
(a) Weight of a platinum wire	= 61.0
(β) " " " with bead of phosphoric acid	= 131.0
(γ) Weight of roasted <i>smaltine</i> dissolved in (β)	= 2.5
(δ) " this wire with bead coloured rose-pink with (γ)	= 118.5
(ε) Weight of bead and wire with fresh phosphoric acid	= 121.0
(f) " sodium carbonate required to colour (ε) blue	= 16.5

8. These data would, of course, give a similar result. Roasting before O.P. on *aluminium plate* is so rapid and efficacious that the whole process only occupies about half-an-hour; with the *roasted powder*, about a quarter of an hour. A drop of water is placed on the powder to retain it under the blast.

In roasting, *nickel oxide* appears yellowish-green on the surface, and might possibly be mechanically separated at this stage of the procedure.

COBALT SOLUTION. (See SOLUTIONS.)

COLOURED FLAMES. (See PYROCHROME.)

COLUMBIUM. (See NIOBIUM.)

COMPASS, EQUATORIAL, to detect combined iron. (See MAGNETIC NEEDLE.)

COPPER, to detect. (1.) Treat a trace of the finely-powdered assay on a bead of H_2B in O.P. The yellow-green pyrochrome of H_2B is *instantaneously replaced by the blue-green one* of cuprous oxide. The metal is detected in any combination or quantity by this extremely delicate and rapid reaction.

(2.) The crushed assay, previously roasted if a sulphide, is placed under a fragment of soda on bare aluminium plate, and treated in O.P. The characteristic red sub-oxide appears at bottom of the bead, formed next the plate, and can be further reduced to metal if the red-bottomed bead be treated on a charcoal slip. This method is very effective in the case of such assays as *Bournonite*.

(3.) Treat the assay as in (1), and if the bead of H.B. be so opaque as to conceal the nature of the borate balls formed, boil it in an Al. capsule or Berlin basin, empty the contents on a blotting pad, and treat the extracted balls on a fresh H.B. bead in H.P. The black copper-borate balls are surrounded by a slight opaque red suffusion (of cuprous oxide). To extract these from among cobalt or iron-borate balls, vesiculate the bead (see VESICULATION), and pick out the copper-borate balls with forceps; or this may possibly be done with the opaque bead above mentioned. The extracted balls are now carefully dissolved in the bead, B.B., by the addition of just sufficient soda, when the bead is *green hot, and green-blue cold*.

CRYSTALLISATION, PYROLOGICAL, to induce. (1.) A flux is made by adding, B.B., about one-third of its weight of powdered fluor spar to a bead of phosphoric acid, which combination affords after P.P. a clear, highly refractive bead. A trace of powdered silica or alumina dissolved in this bead by O.P., and the bead then briefly treated with H.P. immediately induces crystallisation. In the case of silica, large—compared with the size of the bead—white, opaque, prismatic crystals, with slightly pointed ends like maggots, cover the bead inside and out. In the case of alumina the crystals are sometimes crossed,

and with a large trace of alumina well dissolved by strong O.P., the bead then treated with P.P., and lastly with H.P., some beautiful crystals—crosses like those of *Staurolite*, opaque white, floating in the transparent brilliant bead—appear. In both cases, tabular four-sided prisms, clear and colourless, apparently due to fluoride of phosphorus, appear on the surface of the bead.

(2.) Igneous crystallisation may also be induced by applying to the anhydrous calciboric ball (see under CALCIUM), sustained on a platinum wire ring, a small trace of fresh, slightly-calcined lime, silica, alumina, ceric or didymic oxide, under O.P., when minute transparent sphericles are ejected, which first glow white-hot in the O.P. like little stars. If one of these be caught, and applied under O.P. to a calciboric ball, apparently anhydrous crystallisation is instantaneous, and spreads over the whole ball with marvellous rapidity.

CUPELLATION, BLOWPIPE. (See FUMING, LEAD.)

DECREPITATION, to cure. Cover the fragment with cold distilled water on the ledge of the aluminium plate. Then direct a powerful O.P. on the top of the fragment through the water, which boils and evaporates round it; the plate is then to be slanted, so that the water from the cooler part runs round the hot fragment, which is kept at the point of the O.P. all the time. If it begins to turn red-hot its decrepitation is cured; but if it still shows signs of the latter, fresh water is to be poured over it with the dropping bottle, and the O.P. resumed.

*ALPHABETICAL LIST OF SOME DECREPITATING
MINERALS.*

<i>Anglesite.</i>	<i>Conichalcite.</i>	<i>Plumbo-gummite.</i>
<i>Aragonite.</i>	<i>Diaspore.</i>	<i>Stephanite.</i>
<i>Barite.</i>	<i>Diallogite.</i>	<i>Samar-skite.</i>
<i>Bournonite.</i>	<i>Eulytite.</i>	<i>Stolzite.</i>
<i>Boulangerite.</i>	<i>Erynite.</i>	<i>Spaniolite.</i>
<i>Calamine.</i>	<i>Evansite.</i>	<i>Turgite.</i>
<i>Caleite.</i>	<i>Fluor Spar.</i>	<i>Tyrolite.</i>
<i>Celestite.</i>	<i>Galena.</i>	<i>Turquoise.</i>
<i>Cheneviscite.</i>	<i>Mendipite.</i>	<i>Triphyllite.</i>
<i>Chalcophyllite.</i>	<i>Miargyrite.</i>	<i>Vanadinite.</i>
<i>Chrysocolla.</i>	<i>Polycrase.</i>	<i>Wulfenite.</i>
<i>Claustralite.</i>	<i>Pseudo-malachite.</i>	<i>Zorgite.</i>

DIAMONDS, ARTIFICIAL, *to make.* Heat a fragment of caustic lime, of a size proportioned to that of the stone required, in O.P., at the bottom of a bead of pure boric acid. A colourless and highly refractive ball is formed inside of the bead, from which it is to be extracted by boiling water; the bead being very soluble, the ball utterly insoluble in that. The ball should be repurified in a fresh H.B. bead, and more caustic lime added until it is the required size, and can be then again extracted by boiling water. The ball can be coloured by oxide of cobalt or chromium, sesquioxide, &c., while in the bead, if it is required to imitate sapphires, emeralds, &c. It is a curious coincidence with regard to these anhydrous lime-borate balls, that they are, although perfectly spherical while within the bead, often extracted from that with a curved edge, formed by the meeting of two contiguous curved facets, like the natural form of many diamonds. This structure, as regards the balls, certainly seems crystalline, and must therefore be of a

pseudomorphous nature, derived probably from the differential cooling of the outer case of boric acid.

DIDYMIUM, *to detect.* Didymium is never met with naturally without cerium. Chemically prepared didymia from Görlitz is a pinkish-white powder, turning yellow in P.P. It forms a strawberry-coloured clear ball in H₂, which, if saturated, evolves beautiful white prismatic crystals, pointed at end. The clear ball affords an interesting spectrum. Thick black lines to the right (or green side) of D, and those on either side of Eb, are so powerful as to cause the spectrum to appear like a ladder with thick black steps, and when the solution is very strong, an intense but not thick black line appears near that of lithia in the solar spectrum. Di. cannot be wholly separated from Ce. (See BANDS, ABSORPTION, and CERIUM.)

DISTILLATION of water in the field. (See GLASS STILL.)

EARTHS, ALKALINE, *to detect.* (1.) Heat the pearl-sized assay in Pt. tongs or wire in strong O.P. The fragment glows—(i.) White-hot, intensely luminous = pure lime; (ii.) white-hot with yellowish tinge = pure magnesia; (iii.) whitish-yellow = (a) Dolomite, (b) Wollastonite.

(2.) Produce a pure blue pyrocone from a blowpipe candle, and, with the left hand, introduce the previously-calcined fragment (1) into the base of the blue cone and touch the wick with it. The outer mantle of the whole blue cone is tinged red-orange (*lime*), or orange-red (*strontia*).

(3.) Drop cobalt solution on (2) when cool and calcined. If it turns *blue*, lime or strontia is shown; if

green, iron sesquioxide is present in quantity also. (For further proofs, see BORIC ACID.)

EARTHS, COMMON, *to assort rapidly.* After calcination, hold in a good blue H.P. by means of a platinum hook; the pea-sized assay turns *black* (alumina or silica, or both, without much lime). Al_2O_3 blackens in a spirit-lamp flame; SiO_2 does not. (For further treatment, see heads.)

ERBIUM, *to detect.* A pin's-head fragment of pure lime is fused in Hg , and some of the finely-powdered substance suspected to contain erbia treated in this bead under O.P., when the calciborate ball will take up and dissolve the specks, while the bead will not. When the ball has dissolved as much as it can of the assay, the former is extracted by boiling, and examined with a spectroscope (see BANDS, ABSORPTION). A very distinct band in the *green* to the left of Eb is observed. With a very strong solution, several lines, having the appearance of one thick line, quite fill up the space between Eb and E . The ball has a *faint bluish-violet colour*.

FLUORINE, *to detect.* (1.) Dissolve the substance in which F. is suspected as far as possible in an Hg bead; vesiculate the bead while hot (see VESICULATION), breathe on the vesicle in order to supply moisture, and reheat in O.P. *An intense green fluorescent light* shows the presence of very little fluorine, as for instance, the 2 or 3 per cent. contained in *Lepidolite*.

(2.) For a larger proportion of fluorine, "heat a small quantity of the substance with HgSO_4 in a closed glass tube in which a strip of moistened Brazil-wood paper is inserted. The gaseous fluoride of silicon expelled by the

heat, is decomposed by the vapour of water, and a ring of silica is deposited near the assay, while the escaping hydrofluoric acid colours the paper straw-yellow" (Plattner).

(3.) Dissolve about 5 per cent. protoxide of copper in an HP bead, and make the glass green by the addition of fresh phosphoric acid and an application of O.P. Dissolve now a few specks of the powdered assay (also by O.P.). If fluorine is present, this addition will turn the green bead *a beautiful and perfect blue*. This blue colour cannot well be confounded with the green-blue produced by the addition of a sulphate (which see), still less with the blue-green which cupric oxide alone confers upon the HP bead, and that only after P.P. The best way to determine is to examine the three beads together in a bottle by transmitted light.

(4.) Take up a pin's-head fragment of the assay at bottom of a bead of HB, and treat it there with a gentle O.P. *A suffocating smell* of hydrofluoric acid is emitted.

(5.) The assay is treated in the same manner as when Cl. is to be detected (see CHLORINE, 2), only the spot or patch is *green* instead of black.

FLY, to obtain calcium phosphates, &c., from a. Treat the body of the fly, supported on a hot bead of HB, in O.P., when *balls*, opaque and clear (phosphates), vitreous semi-opalescent matter (soluble silica ?), &c., appear in the heretofore clear bead. As it is more difficult, however, to thus consume a whole fly than would be supposed, it is better to begin with the head, and proceed with divisions of the body of an equal size to that, by which means every particle of ash is retained—a result otherwise impossible to realise even in a closed platinum crucible.

Volatile metals seem also thus detectable, for if an ordinary healthy fly be consumed as above, and the resulting bead compared with another in which a fly poisoned on arsenical paper has been burned, a very marked difference can be observed between the two even with an ordinary lens; but such investigations should be conducted under a microscope.

FOIL, ALUMINIUM. (See ALUMINIUM PLATE.)

FOIL, PLATINUM. Every operation formerly performable upon it can be far more easily and safely conducted on aluminium.

FORCEPS are, for convenience of reference, named as follows:—(α) Dentist's forceps (fig. 22) with powerful jaws,



Fig. 22.



Fig. 23.

which should, if possible, be smooth inside, as powder of valuable minerals, &c., is apt to get lost or mixed in a serrated surface, are used for crushing fragments of minerals, hard salts, brittle metals, or alloys, and for squeezing balls of malleable metals or alloys. It thus acts very efficiently instead of a hammer, which need not be taken as part of a blowpipe apparatus. (β) forceps (fig. 23), also a dentist's

implement, are used for nipping off crystals, or projecting parts of a pure mineral for analysis. (γ) forceps (fig. 24),

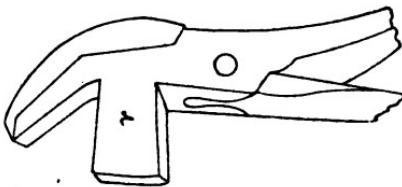


Fig. 24.

combine the use of (α) and (β), and adds besides, a hammer: the round part is useful for pressing out creases in foil of any kind held under flannel or linen rag on a

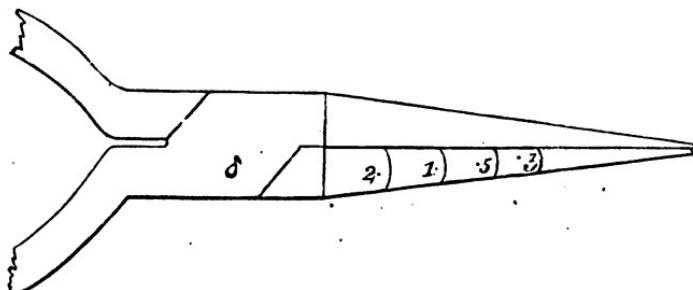


Fig. 25.

table. (δ) forceps (fig. 25) are for making the ring on platinum wire upon which beads are to be formed. It can be obtained (as "cage-makers' pliers") at any ironmonger's, and may be graduated to suit the size of the ring required



Fig. 26.

as shown in the figure. (σ) forceps (fig. 26) are ordinary watchmakers' pliers with closed handle; three or four

strands of wire strapping are fastened round the handle so as to slip up and down that, and thus enable the pliers to hold platinum wire, as well as clean it by drawing it gently and repeatedly through the flat part of the legs. (ζ) forceps, with platinum tips (see PLATINUM TONGS). (η) forceps are like the (ε) ones, but have crooked legs for holding basins with boiling water over a spirit-lamp

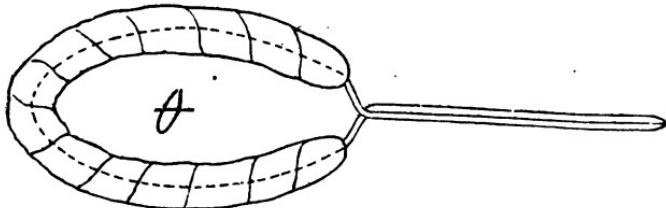


Fig. 27.

flame or blowpipe pyrocone. (θ) forceps (fig. 27) are pressure-opening, and have flannel list wrapped round the handle, which becomes very hot. They are for holding Al. plate in operations, and may have one leg

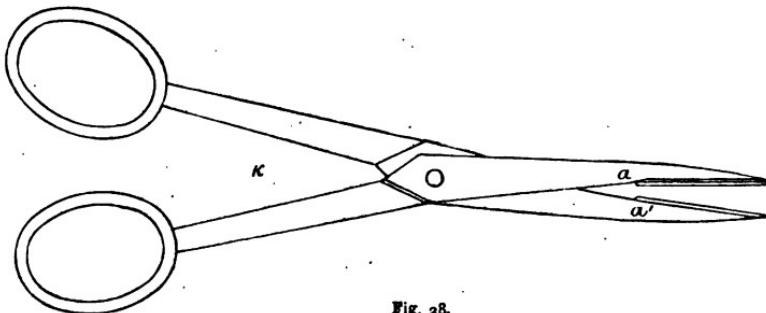


Fig. 28.

polished or burnished to show delicate high ascending sublimates. (κ) or candle forceps (fig. 28) are a pair of

scissors with the points flattened to squeeze the wick of a candle at *a*, while acting as snuffers.

FUMING, LEAD, manipulation in. A paste of the crushed mineral or oxide is plastered in the hole of a "keyhole mortar" (which see); a few specks of proof lead laid upon that, and some more of the assay paste plastered over all with a penknife. If the assay be a metal or alloy, a piece of it is merely laid alongside the lead. The mortar, thus charged, is placed on the ledge of an aluminium plate, which has been previously well cleaned, held in the muffled or (θ) forceps. A strong O.P. is now directed on the mass in the mortar, which is kept just within the point of the blue pyrocone, so that the pyrochrome (which is thus invariably produced) streams over the mortar, and impinges against the aluminium plate. Wherever this pyrochrome touches the plate, the characteristic sublimate of the burned metal is deposited. After blowing for more or less time, as the metal alloyed with the lead is more or less fusible, the fume or sublimate is observed to be spread in circular form on the long side of the aluminium plate at the back of and round the assay, in the shape of a halo, which seems, whatever other colours it possesses, to be invariably terminated by a white, or nearly white border. This white border is scraped gently and carefully off with a smooth-edged penknife, so that the aluminium is not scratched, and placed on an agate slab in two portions, one of which is to be tried in an Hg , and the other in an HP glass, under O.P. After all required for this analysis has been scraped from the sublimate, a small clean paint brush, holding a drop of distilled water, should be applied to the most highly coloured part, and that, well mixed,

thus transferred to white paper in a small square of colour, thus : "Lead + Silver = □; or Lead + Cobalt = □." The colours (generally constant) of particular compound sublimates may be thus noted, as well as (by a written description or pigmental copy) those of the dry sublimates on the plate, which of course are much more brilliant than the "fume" mixed with water can be. The fume of lead fused with CoO containing only 5 per cent. of NiO, gives an HP glass of a much paler, and indeed, different pink tint, to that of the pure plumbo-cobalt fume glass: the latter in HP produces opaque lavender-blue; the former, opaque slate colour.

But the whole method of lead fuming is in its babyhood as yet, having been practised (apparently) only by myself. It is, at all events, satisfactory to find from it that the theory upon which the practice of cupellation is based is probably erroneous, and that a certain proportion of every metal (except, perhaps, iridium) goes up with the lead. The so-called "phenomenon of brightening" in cupellation seems due to the fact that the fluid oxide of lead (litharge) spins round the surface of the metallic ball in a coating which, following the ordinary optical law of "interference," becomes more iridescent as it gets thinner, while the ball itself is all the time stationary, and, protected by this coating, only in a state of *red* heat. The moment the coating is finally removed, the "button" underneath, no longer protected from the high temperature, glows *white* hot. Some pyroxides affording highly-coloured sublimates, as that of gold, are indeed best detected by this method, as there is no necessity to scrape off anything from the Al. plate, but all silicious matter must be previously removed by means of a ball of platinum. (See GOLD.)

GENERAL RULES for *pyrological examination.* (1.) Never attempt to learn, in the first place, reactions of particular substances, whether *per se*, or with fluxes, by means of minerals, however pure those may be supposed to be, but only through chemically pure *oxides*.

(2.) Do not throw away the *results* of successful experiments, but keep each specimen in one of the corked penny tube-bottles filled with turpentine, which prevents oxidation, and write the chemical symbol on the cork.

(3.) Keep your reagents in small *fragments*, not in powders; the latter is apt to be contaminated with dust, &c., in a room, and if it happen to be spilled, is irrecoverably lost, but fragments can be picked up again.

(4.) You *cannot* use too small a fragment of the assay at one time for flux testing, especially in boric acid. More can always be added if necessary, and an assay is, in nine cases out of ten, spoiled by taking up too much powder at once, on the bead or glass.

(5.) *Dual Examination.* It is an excellent plan, when the detection of one constituent of a mineral or compound gives a general idea of its nature, to place a fragment or some paste of the pure pattern oxide or salt alongside the former on the Al. plate; or in a contiguous bead of boric or phosphoric acid, so that simultaneous treatment of the two may show the distinction between them. For instance, some white oil paint was suspected by the effect of O.P. on it, to be not pure lead carbonate. Some of this, chemically pure (*a*), was therefore mixed with painter's oil, &c., and placed alongside a fragment of the suspected paint (*b*) on aluminium plate, and treated with O.P. Both afforded the plumbic blue pyrochrome and pale-yellow sublimate on the

plate (see LEAD); but (a) far more strongly than (b). In about twenty seconds (a) fused to a shining ball with a crust of litharge on top, while (b) glowed like one of the "earths," emitted a pea-green pyrochrome (*Ba*), with a dry yellow

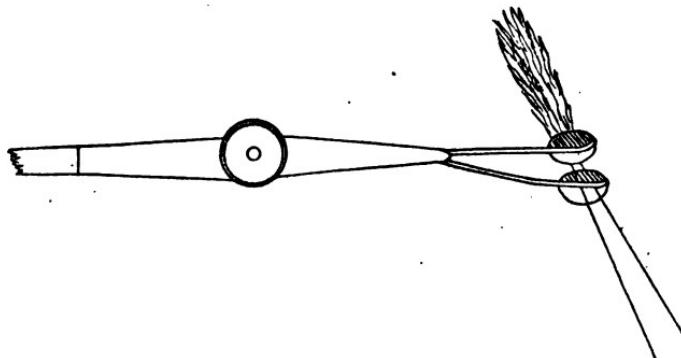


Fig. 29.

incrustation on the off side, and a few extremely minute balls of lead underneath, while the greater part remained a white mass, which afforded with soda a pink ball (*S*). Thus, in a few seconds, the paint was seen to be adulterated with barite. (Fig. 29 shows dual examination in HB.)

GEOMETRICAL PENS make excellent *holders* for the platinum wire, fragment hook, and for thread saws, &c. (See PENS, GEOMETRICAL, and fig. 29.)

GLASS, MAGNIFYING. (See LENS.)

GLASS MEASURE, *Harkort's.* Sometimes, but seldom, useful for taking approximately a certain quantity of powder loosely filled in.

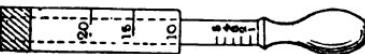


Fig. 30.

GLASS SLABS, for keeping oxides, &c., on. Round or square pieces of glass, having chemical formulæ or other

useful symbols engraved *backwards* on one side, so that, when turned over, the letters are correctly exhibited through the glass.

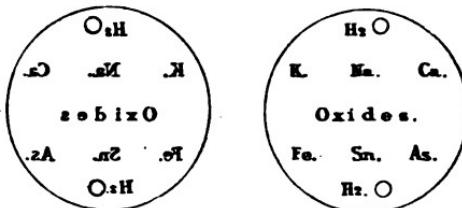


Fig. 31.

GLASS STILL, for distilling small quantities of water or watered spirit in the jungle. Two glass U tubes with a bore of .3 inch, 5.5 inches long, each having the left side of the U bent over at top for two inches for connecting purposes, so that the entire breadth of the U at top is $3\frac{1}{2}$ inches, and at bottom 2 inches, are fitted, one into a small washing bottle two-thirds full of drinking water, so that the bent end of the U passes right into the neck of the bottle, and is retained there by a loosish piece of vulcanised tubing. The straight leg is fitted to the bent end of a similar tube with a light piece of elastic tubing.

The apparatus is now placed with the first U dipping into a tea-cup or other vessel full of cold water, which will not crack by proximity to the spirit-lamp put under the washing bottle which hangs over the side of the cup. The second U dips into another cup or tumbler of cold water, and contains the product distilled.

When this is considered sufficient, the bottle is gently and easily detached without previously putting out the

spirit-lamp — which would cause atmospheric pressure at the other end of the tube to force back the distilled water into the bottle—by slipping the glass tube out of the vulcanised one, which remains firmly fixed round the neck of the bottle. (See WATER.)

GLUCINUM, *to detect.* (1.) Beryllia does not decompose a calcium-borate ball in a bead of HB as alumina does (see ALUMINA), and this rare earth can be mistaken for nothing else. Ordinary (Freiberg) beryl, treated thus in HB with a fragment of lime, evolves at first some white streaky matter (decomposition of the lime ball by the alumina present), and the remaining ball is clear under strong O.P., but on cooling, semi-opaque, white, and highly crystalline. The ball is extracted by boiling, and treated in a fresh HB bead with a strong O.P.; the ball emits no opaline matter, and remains unaltered.

(2.) Assumes a pale bluish-grey colour after cobalt solution.—P.

GOLD, *to detect.* (1.) *With silica or earthy matter.* The quartz or mineral suspected to contain gold is crushed with (α) forceps, and afterwards to a paste with water between agates (see AGATE SLABS). The paste is then intimately mixed with an equal bulk of any reducing flux, as potassium cyanide and soda—Plattner's "Reductionsmittel" flux, sodium carbonate 10 parts, potass. carb. 13 pts., powdered borax 5 pts., dry starch powder 5 pts., answers admirably—and fused until the slag formed is quite fluid, in a charcoal mortar, in a weak H.P., so as to occasion no sublimate, with a piece of platinum foil 40 mgrs., and proof lead 10 mgrs., weighing together

about 50 mgrs. The resulting metallic alloy ball is to be rolled well about under H.P. among the melted slag for the purpose of collecting in itself all metallic particles. It is then rapidly taken out with the (s) pliers from the melted flux, placed on an agate slab to cool, and there squeezed with the (a) forceps gently, to free it from all particles of slag, and gently rubbed between the finger and thumb, transferred to a fresh charcoal mortar, and treated on a clean Al. plate with a powerful O.P. from a hand-blower. The presence of gold, even in the minutest proportion, is betrayed by a *pink coloration* in the resulting plumbic sublimate. As the charcoal burns low, care must be taken that the alloy ball, in a state of white heat, does not roll out on to the hot aluminium, as in that case the great conductive powers of the latter metal will be overtaxed, and the platinic red-hot ball will eat a hole in it; or the Al. plate may be rested on a sponge or cloth kept damp with cold water. Some platinum contains traces of gold, and then gives a faint-pink tinge to the sublimate, so that it may be as well to test it in the first place. The pink part, and all the sublimate above it (which is generally white), is now scraped gently off with a penknife, placed on an agate slab, and treated in an H.P. bead with P.P., when a *pink coloration*, turning with H.P. to *gold spangles*, shows further the presence of the noble metal. Trifling quantities of silver, which also afford a pink sublimate when lead fumed on Al. plate, are here distinguished from gold. (See SILVER.)

(2.) *In alloys.* Proceed as above, without the reducing flux, only more proof lead will probably have to be added before getting rid of any "baser" metals, which all sublime

before gold will. To facilitate and shorten this operation, the gold should first be roughly separated by the method described under the head of "Alloys (1)," the gold part cut off with a penknife or the (β) forceps, and lead fumed as above.

(3.) According to Plattner (pp. 541-560), a trifling proportion of gold may be detected in an ore by several concentrations (after roasting, &c.) in assay lead and then cupelling that, but this is at best a tedious process, entailing moreover, as we have seen, a loss of gold which would not be observed if the operations are conducted on a cupel.

In the methods above described, (1) and (2), a loss of platinum also occurs. In one assay I made in 1878 for the purpose of standardising the loss of gold, an alloy ball composed of Pt. 53 mgrs., Pb. 20.3 mgrs., Sb. 9 mgrs., Au. 3.7 mgrs., after affording several fine crimson sublimes on aluminium plate, only weighed 30.8 mgrs.; and it was obviously, from its physical properties as well as the fact that it had been treated on eight charcoal mortars before O.P., composed almost entirely of platinum; but this loss of platinum would not, of course, interfere with a quantitative estimation of the gold which is determined by its loss. On the 7th December 1878, I mixed all sublimes obtained in these gold processes with about an equal bulk of "reducing flux," and fused the mixture, B.B., on charcoal to a large yellowish platinic-looking ball.

Hutchings says (*Chem. News*, xxxvi. 219) that "the red Pb. + Au. sublimate seems simply that of gold over lead;" but if he had scraped off and tested some of the *white* sublimate as above recommended, he would have found gold in it also. Again: "Ross attributes the colour to oxide of

gold formed and volatilised by the action on the gold of the lead oxide produced." I feel sure Mr. Hutchings cannot point to anything written by me inferring that the "action" of lead oxide before the blowpipe could oxidise gold. My reasons for supposing gold sublimate to be a true oxide are :—(a.) It is producible, B.B., in a manner in no way differing from that in which oxide of zinc is produced. (b.) It exists (as Mr. Hutchings himself admits) as a phosphate in a bead of phosphoric acid. (c.) This phosphate can be, as I have before mentioned (*Pyrology*, p. 287), precipitated from its solution as a white powder, and reduced to metal, B.B., on charcoal. (d.) The plumb-auric sublimate can be reduced and oxidised backwards and forwards in a bead of phosphoric acid, from a red tint to yellow metallic spangles and *vice versa*, by H.P. and P.P., at the will of the operator, as I have often done myself, only some care and sometimes a little fresh phosphoric acid is necessary to reproduce the red tint.

HYDRATES communicate a *dimness* to H₂ beads, B.B., and a *yellow* colour to flame. (See SODIUM.)

HYDROCARBONOUS PYROCONE. (See PYROCONES.)

HYDROGEN GAS, used as a vehicle for the detection of sulphur combined with oxygen in compounds. The sulphate, as, e.g., *Gypsum* or *Alunite*, is held as a pasty mass on an Al. spoon, treated with a candle H.P. (as coal-gas generally contains sulphur), and a drop of water placed on the hot mass. *A smell of rotten eggs* (H.S.) *rises with the steam.* (See SULPHUR.)

IODINE, to detect. (1.) Heat the assay with acid potassium sulphate in a glass tube closed with the forefinger. A *violet vapour* fills the tube.

(2.) Treat some of the assay made into a paste, with powdered sulphur and bismuth in a C. mortar on Al. plate. A *brick-red* sublimate appears.

IRIDIUM, *to detect*. It seems the only metal which, when lead fumed, affords *no evidence* of its presence in the sublimate by means of reagents. (See **OSMIUM**.)

IRON, *to detect*. (1.) Crush a fragment of the assay in (a) forceps, mix to a paste with sodium carbonate, and fuse the mass in a candle H.P. on Al. plate. A very small trace of ferric oxide communicates to the white soda ball a *yellowish-brown tint*. A larger proportion of iron oxide gives it a reddish-brown colour. All that is necessary is to hold the assay—which may have in P.P. reacted turquoise-blue for manganese, or grey-blue for cobalt—in a pure candle H.P., when, on cooling, those colours disappear from the bead, and that of iron, or sulphur, or ferric sulphide, appears. In the case of sulphides (which communicate thus treated a salmon-pink to soda—see **SULPHUR**) the assay is previously roasted *per se* in a strong candle P.P. on Al. plate; a drop of distilled water added and roasting repeated, until, part of the sulphur being apparently volatilised, sulphates are formed which, as *Gypsum*, afford with soda, even after considerable H.P. from a candle on Al. plate, only a bluish-white and peculiarly crystalline bead cold, provided no iron is present, but in the latter eventuality the bead becomes *yellowish-brown*. Ferric oxide is thus quite readily detected in such minerals as *Smaltite*, *Chalcopyrite*, *Boulangerite*, *Bournonite*, &c.; any copper present being reduced, even in O.P., and found as metal in the soda ball next the Al. plate. If silica is present with cobalt oxide, a blue

glass is sometimes formed which conceals the iron reaction : in this case it is only necessary to crush this glass with the (α) forceps and agates to a fine powder, and to treat this powder in a candle H.P. with an excess of soda, when the iron reaction soon appears.

(2.) Potassium carbonate gives, with the minutest speck of pure rust, a *pink-tinged bead* on Al. plate after P.P., while sulphur affords a nearly similar tinge to a like bead after H.P., a reaction which supplements (1) well, and may be made confirmatory of it.

(3.) A few specks of the powdered assay are heated, first in O.P., then in H.P., in a bead of HB. If *brown-black* balls are formed with a *rusty opalescent matter* clinging to them, iron may be suspected. If the balls are too minute to be separated by boiling water and blotting pad (see BORIC ACID), a pin's-head fragment of lime is added to the bead ; the suspected ferric balls are dissolved by means of O.P. in the large transparent lime-borate ball. It is coloured *olive-green* on cooling—faint or strong, according to the proportion—by iron protoxide. This is the most delicate known test for minute traces of iron, which can be thus detected in part of a grain of wheat, of a fly, or in a single hair, &c.

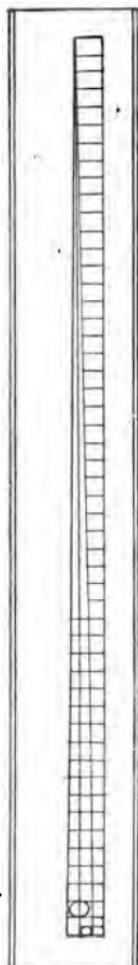


Fig. 32.

(4.) Considerable quantities of iron oxide are detected by the *magnet* (which see). If it does not exist in the state of magnetic oxide, O.P. soon converts any other into that.

IVORY SCALE. A modification of Harkort's scale for measuring the diameter of gold and silver "buttons" (see Plattner) is sometimes used by me with an extra converging line, for determining the diameters of anhydrous borate balls which appear to differ according to the *nature* of the base; baryta, for instance, giving a larger ball than lime. The balls should be extracted by *cold* water for measurement. (Fig. 32.)

LAMP, BERZELIUS'S, need not be described here, as it is purchasable at any good analytical chemist's. It

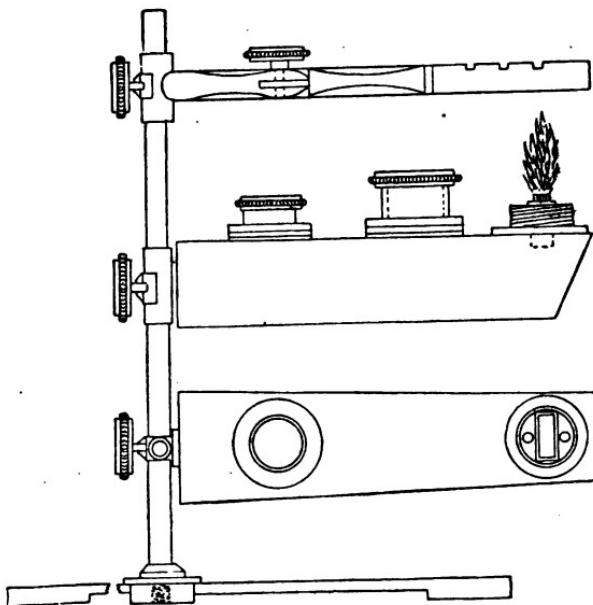


Fig. 33.

affords very good pyrocones when filled with pure cocoanut oil, which congeals at a temperature of 70° F., but

it is inconvenient, even with this difficultly procurable oil, in hot climates, on account of the oil leaking, besides which, the necessary extra supply might also occasion damage to articles in a box. (Fig. 33.)

A pupil of mine, M. Lombardi, has proposed an excellent, simple, and cheap blowpipe lamp, made of the end of an ordinary iron gaspipe, in which the wick is held on one side of the interior by a piece of bent zinc foil. This lamp has, in fact, much the appearance of the bottom part of my round pyrological candle (fig. 18). Old candle ends, melted suet, or fat of any kind can be used as fuel for this cheap and excellent lamp; but its weight is equal to at least two of my candles. (See CANDLES.)

LANTHANUM, to detect. When the assay has been treated as described under Cerium (see CERIUM and DIDYMUM), and the strawberry-coloured balls of apparently nearly pure didymic borate extracted from the last bead of $\text{H}\ddot{\text{B}}$ by boiling water, *bluish fragments*, also insoluble and transparent, seem to separate from the outer circumference of the ball, which, in a fresh $\text{H}\ddot{\text{B}}$ bead, form *violetish-blue balls*. These may be lanthanic borate.

LEAD, to detect. (1.) Heat a small pea fragment on the bare aluminium ledge in O.P. as long as it affords a sublimate, which, not being that of lead, should be separated here, and may be examined in $\text{H}\ddot{\text{B}}$ for antimony or bismuth, &c. In this operation, if continued, sulphur, selenium, &c., are, for the most part, eliminated. The assay is now placed on a charcoal slip, and treated, first with O.P., to observe the *pyrochrome*, which from Pb. is *blue*. It is then treated with a long P.P., by which means any Sb. or Bi. present is brought to the front

of the ball, which must not be fused sufficiently to spin round, as the easiest oxidised metals always approach the source of heat. (See ALLOYS.) The sublimate of this part of the ball is first tested on the plate with O.P., when if it blacken, antimony is present. Part is now scraped off the plate and tested in an HB bead before O.P. Lead and antimony sublimes leave a *clear bead on cooling*; bismuth and the other volatile metals, an opaque white bead. Bismuth affords yellowish-brown streaks like those of a slice of agate by transmitted light. (See BISMUTH.) According to Hutchings (*Chem. News*, xxxvi. 217), by heating an alloy of Pb. and Sb. directly on Al. plate, antimony is obtained (as sublimate) practically free from lead. "If very little Sb. is present, the bit of lead is best placed on the plate, together with a bit of fused boric acid about half its size, and the two heated very strongly; nothing at all will be obtained for some time, but as the heat of the plate increases, a small, pure, white Sb. sublimate will form slowly. The boric acid serves the double purpose of holding the little ball of lead on the plate in the blast from the blowpipe, and of taking up what little oxide of lead is formed. It is in cases like this that the superiority of aluminium plate is most apparent. An amount of antimony that would be completely dissipated on ordinary charcoal, is here condensed into a small compact sublimate, and when so little is present as to give only a barely distinguishable film, it is proved to be antimony by its instantly blackening in R.F."

(2.) The same author states that the pure lead sublimate on Al. plate is as follows :—"In front of the assay is first a narrow strip of pale yellow which passes into orange, and

this into a band of deep coffee brown, shading off into yellowish-brown. Outside of all and on the ledge is a thin white sublimate. In P.F. the pale yellow and orange are rapidly turned deep brown. The outer white is also strongly browned. All portions of the sublimate *retain the brown colour on cooling.*" (See BISMUTH.) Lead generally contains silver, which is betrayed in the merest trace by a rose tint on the Al. plate, but an appreciable quantity is best proved by an HP bead. (See SILVER.)

LEAD FUMING. (See FUMING, LEAD.)

LENS. The common shape used by watchmakers, but having much greater magnifying power, is far more efficient and handy than that usually put up in blowpipe cases, which has two glasses moving on a joint, eye-glass fashion. The accompanying figure represents a watchmaker's lens, with reflecting collar, and a bead placed in it for examination.

LIME. (See CALCIUM.)

LIME REAGENT, to use. Clean egg shells are best. When required for use, a fragment is held in the platinum forceps before O.P. until perfectly calcined; it is then gently broken on an agate slab into pieces of the required

size. The calcium-borate ball formed by one of these pieces in HB is an important reagent for the detection of

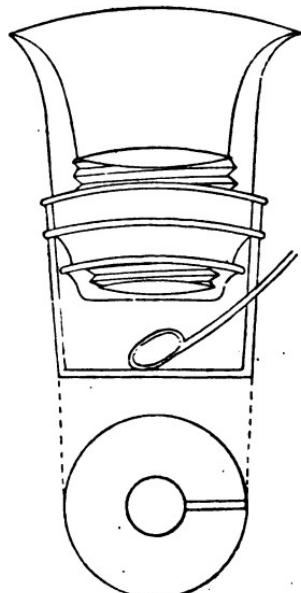


Fig. 34.

traces of alumina (see ALUMINA and SILICA), and the rare earths, erbium, &c. (see BANDS, ABSORPTION). One of these balls will also, by its greenish colour, show distinctly the iron in half a grain of wheat! (See IRON, 3.)

LITHIUM, to detect. (1.) Gently heat the fragment or powder on platinum wire in a long P.P. from a candle or lamp so that it may be thoroughly dried, but it should not be fused; then, without discontinuing the pyrocone, rapidly shift the partially caustic or desiccated assay, introduce it at the base of the flame, and touch the wick with it. *The whole pyrocone is tinged "blood-red" or red-violet*, as for instance, thus by Petalite.

(2.) Lithia, although only present in small proportion, changes the green pyrochrome of Hg to violet.

(3.) Lead-fumed lithia affords a *sublimate* which gives in Hg beautiful *opaque white balls*, which may be observed with the lens to be clear for a considerable time in the hot bead, and are not dissipated nearly as soon as those formed by potash or soda.

(4.) Turner's test for boric acid (see BORIC ACID) answers for lithia, when both these substances may be detected in the same mineral as in *Tourmaline*.

LORGNETTE, SPECTRUM. (See SPECTRUM LORGNETTE.)

MAGNET. A small horse-shoe one is best.

MAGNETIC NEEDLE. Heat a steel knitting needle gently in its centre over a spirit-lamp, and (with a pair of gloves on, as it becomes very hot) bend it in the centre to a right angle. Then magnetise this rectangular needle in the ordinary manner from centre to poles, and suspend it horizontally from its centre of gravity, found by means

of a thin brass wire, by a silk thread. This needle, called by me "the equatorial needle," as the bisection of its angle points east and west, is so sensitive that *Molybdenite* and *Graphite*, when containing iron, easily move it.

MAGNESIUM, *to detect.* (1.) Treat a speck or two of the crushed calcined fragment on a bead of H_2B with O.P. *Opaque white balls* float, like miniature snowballs, within the clear bead. Some calcium phosphates also form opaque (instead of clear) balls in H_2B . To distinguish between these, a strong O.P., best made with a hand-blower, is directed on the bead, and made to play as much as possible on the contained ball or balls. Magnesium borates, after some blowing with this, become clear like calcium borates, but on the addition of fresh boric acid to the bead, the former ball becomes *opaque and white again*. In presence of a considerable quantity of lime, as in the case of *Dolomite*, magnesian borate balls are clear when cold from the first, but unlike those of lime, *opaque white*, or, if iron is present, yellow, *hot*. Moreover, alumina added B.B. to the bead, does *not* render the whole bead milk-white. (See **ALUMINA**, 2.)

(2.) Heat a fragment in platinum tongs or wire gently in O.P., drop a little Co. solution on it when cool, and apply O.P. strongly. The fragment turns *pale flesh-red*, but this test will not answer in presence of lime or alumina, iron, or other metallic oxides (Gahn).

(3.) According to Plattner and Brush, carbonate of lime (*Calcite*) "fuses to a clear glass" with soda B.B. on platinum foil, while magnesia as in *Dolomite* does not, but I have not found the former reaction take place.

MANGANESE, *to detect.* (1.) Take up a trace of the

finely-powdered substance on an intensely red-hot bead of H.P. *Bubbles with crimson-red sides appear* in the bead at the point of contact. If effervescence has not taken place, the off side of the bead is to be momentarily heated in P.P. until effervescence takes place. This reaction (due to the intense oxydising properties of H.P.), which does not require the splinter of nitre necessary with borax, is perhaps even more delicate for Mn. than the next one mentioned, and, unlike it, is efficacious even in presence of cobalt.

(2.) Heat a pin's-head fragment of the assay (as fine powder might form solutions of other oxides) along with a pea fragment of soda on aluminium plate or spoon in P.P. The fused ball is coloured *pale turquoise-blue*. After H.P. manganese dioxide is apparently again formed as *black-brown spots*. If silica and cobalt are present so that a blue glass is formed, disguising the Mn. reaction, crush the assay again with a larger quantity of soda and repeat the operation.

(3.) Treat a speck of the finely-powdered assay paste in O.P. on an H.B. bead. After *effervescence, black, opaque, vitreous balls* are formed, which, after a short treatment in O.P., become *transparent* and coloured *nut-brown*; after the application of H.P. to the bead, these nut-brown balls become colourless.

(4.) An H.P. bead having .5 per cent. of MnO₂ dissolved in it under P.P., is *pale violetish-red*, about the tint of a pink topaz, and 1 per cent. colours the bead a *splendid carmine*. H.P. renders the bead *colourless*.

MANGANESE SOLUTION. (See SOLUTIONS.)

MATÉRIEL, alphabetical list of.

Agate slabs; ditto mortar. Aluminum plate; ditto spoon. Alphabetical note-book. Anvils, open and closed. Bottles, dropping; ditto assay; ditto oxide; ditto cobalt and manganese solution; ditto spirit-lamp. Brushes, paint. Basins, boiling. Crushers, *vide* FORCEPS. Colour box. Forceps, (α) crushing; (β) cutting; (γ) pyrologist's; (δ) ringing; (ϵ) holding and picking; (ζ) platinum; (η) boiling; (θ) aluminum plate; (κ) lamp. Files. Glass still, tubes, measure, funnels, slabs. Geometrical pens. Hammer, geological. Ivory spoon; ditto scale. Lens. Magnet, rectangular. Mortars, charcoal. Platinum wires, foil, spoons, spatula, crucible with lid. Pipette. Pyrological portfolio. Prism, blackened. Penknife. Spirit-lamp, bottle. Saws, fine. Scissors, pyrological. Sieves. Sponges, small. Suckers, blotting-paper. Spectrum lorgnette. Test papers, blue, red, and yellow. Test tubes.

MEASURE, GLASS. Sometimes useful in qualitative examinations for taking sufficient "reducing flux" to bring sublimates, &c., to metal. (See ALUMINIUM PLATE.)

MERCURY, to detect. (1.) Heat a little of the powdered assay or piece of the amalgam in a closed glass tube, having a strip of gold leaf hanging in it, and heat gently over a spirit-lamp or the base of the blue pyrocone. The smallest trace of mercury *turns the gold white*.

(2.) Mercurial assays afford on Al. plate from charcoal slip the well-known characteristic white sublimate on being very gently heated, which, though it appears pulverulent without a lens, is, in reality, composed of myriads of minute balls of mercury which can be scraped into larger, and therefore visible, balls with the back of a penknife if mercury exists in any quantity.

MINERAL, testing table of combinations.

1. ALUMINIUM. (a) With OXYGEN—*Corundum, Diaspore.*
 (β) With FLUORINE—*Cryolite, Chiolite.*
 (γ) „ PHOSPHORIC ACID—*Turquoise, Wavellite, Attacolite, Childrenite, Cirrolite, Peganite, Fischerite, Tavistockite, Augelite, Amblygonite, Lazulite, Callainite, Plumboresinite.*
 (δ) With SULPHURIC ACID—*Aluminite, Alunite, Lowigite, Kalinite, Mendozite, Tschermigite, Pickeringite, Apjohnite, Bosjemanite, Italotrichite, Copiapite, Voltaite.*
 (ε) With SILICIC ACID—*Cyanite, Andalusite, Sillimanite, Staurolite, Orthoclase, Tourmaline.*
 (ζ) With SILICIC ACID and WATER—*Pholerite, Allophane, Kaolin, Pyrophyllite, Meerschaluminite.*
 (η) With SILICIC ACID and FLUORINE—*Topaz, Pycnrite.*
 (θ) ALUMINATES—*Spinel, Hercynite, Gahnite.*

2. ANTIMONY. (a) METALLIC—*Native Antimony.*
 (β) With ARSENIC—*Allomonite.*
 (γ) „ COPPER—*Bournonite.*
 (δ) „ LEAD—*Jamesonite, Berthierite, Boulangerite.*
 (ε) „ NICKEL—*Breithauptite, Ullmannite.*
 (ζ) „ SILVER—*Dysscrasite, Proustite, Pyrargyrite.*
 (η) „ SULPHUR—*Stibnite.*

3. ARSENIC. (a) METALLIC—*Native Arsenic.*
 (β) With COBALT and NICKEL, &c.—*Smaltite, Millerite.*
 (γ) „ OXYGEN—*Arsenolite.*
 (δ) „ SULPHUR—*Realgar, Orpiment.*
 (ε) As ACID with BASE—*Erythrite, Annabergite.*

4. BARIUM. (a) With CARBONIC ACID—*Witherite, Barytocalcite, Bromlite.*
 (β) With MANGANESE—*Psilomelane, Braunit, Hausmanite.*
 (γ) With SILICIC ACID—*Harmotome, Brewsterite.*
 (δ) „ SULPHURIC ACID—*Barite, Barytocelestite, Dreelite.*

5. BISMUTH. (a) METALLIC—*Native Bismuth*.
- (β) With CARBONIC ACID—*Bismuthite*.
 - (γ) „ COPPER—*Emplectite, Annivite*.
 - (δ) „ LEAD—*Chiviatite, Kobellite*.
 - (ε) „ NICKEL—*Grünanite, Rammelsbergite*.
 - (ζ) „ OXYGEN—*Bismite*.
 - (η) „ PHOSPHORIC ACID—*Hypochlorite*.
 - (θ) „ SILVER—*Chilenite*.
 - (ι) „ SULPHUR—*Bismuthinite, Karelinit*e.
 - (κ) „ TELLURIUM and SELENIUM—*Tetradymite*.
6. BORON. (a) With AMMONIA—*Larderellite*.
- (β) With LIME—*Borocalcite, Hydroboracite, Hayesine*.
 - (γ) „ MAGNESIA—*Boracite*.
 - (δ) „ SILICA—*Tourmaline, Axinite, Datholite*.
 - (ε) „ SODA—*Borax*.
 - (ζ) „ WATER—*Sassoline*.
7. CADMIUM. (a) With OXYGEN—*Calamine*.
- (β) With SULPHUR—*Greenockite, Sphalerite*.
8. CALCIUM. (a) With ARSENIC ACID—*Pharmacolite, Kühnrite*.
- (β) With ANTIMONIOUS ACID—*Romeite*.
 - (γ) „ BORIC ACID—*Hayesine, Borocalcite*.
 - (δ) „ CARBONIC ACID—*Calcite, Aragonite, Dolomite*.
 - (ε) „ CHLORINE—*Tachydrite*.
 - (ζ) „ COLUMBIC ACID—*Pyrochlore*.
 - (η) „ FLUORINE—*Fluor Spar, Prosopite, Yttrocrorite*.
 - (θ) „ MAGNESIUM—*Dolomite*.
 - (ι) „ NITRIC ACID—*Nitrocalcite*.
 - (κ) „ OXALIC ACID—*Whewellite*.
 - (λ) „ PHOSPHORIC ACID—*Apatite, Francolite, Pyromorphite, Kunkur, Polysphærite*.
 - (μ) With SILICIC ACID—*Wollastonite, Augite, Scapolite, Prehnite*.
 - (ν) With SULPHURIC ACID—*Gypsum, Anhydrite, Polyhalite*.
 - (ξ) „ TITANIC ACID—*Perovskite*.
 - (ο) „ TUNGSTIC ACID—*Scheelite*.

9. CERIUM, LANTHANUM, DIDYMIUM. (a) With CARBONIC ACID—*Parisite, Lanthanite.*

- (β) With FLUORINE—*Fluocerite, Yttrrocерite.*
- (γ) „ PHOSPHORIC ACID—*Cryptolite, Monazite.*
- (δ) „ SILICIC ACID—*Cerite, Allanite, Orthite.*
- (ε) „ SILICIC and TITANIC ACID—*Tchewskinite, Mazzandrite.*
- (ξ) With TANTALIC ACID—*Fergusonite.*
- (η) „ TITANIC and COLUMBIC ACID—*Euxenite.*

10. CHROMIUM. (a) METALLIC—*In Meteoric Iron* (sometimes).

- (β) With ALUMINA—*Chromic Ochre, Wolchonskoite.*
- (γ) „ GLUCINA—*Chrysoberyl.*
- (δ) „ LIME—*Ouvarovite.*
- (ε) „ MAGNESIA—*Spinel.*
- (ξ) „ OXYGEN and IRON—*Chromite.*
- (η) „ POTASH and SODA—*Fuchsite.*
- (θ) As CHROMIC ACID—*Vauquelinite, Melanchroite.*

11. COBALT. (a) With ARSENIC and IRON—*Smaltite.*

- (β) With ARSENIC ACID—*Erythrine.*
- (γ) „ MANGANESE—*Asbolane.*
- (δ) „ NICKEL—*Siegenite, Grünanite.*
- (ε) „ SELENIUM—*Tilkerodite.*
- (ξ) „ SULPHUR and ARSENIC—*Cobaltite, Jeypoorite, Linnaeite.*
- (η) With SULPHURIC ACID—*Bieberite.*

12. COPPER. (a) METALLIC—*Native Copper.*

- (β) With ANTIMONY, &c.—*Wölkite.*
- (γ) „ ARSENIC—*Darwinite, Domeykite, Condurrrite.*
- (δ) „ ARSENIC ACID—*Olivenite, Chalcophyllite.*
- (ε) „ BISMUTH—*Wittichite.*
- (ξ) „ CARBONIC ACID—*Malachite, Chessylite.*
- (η) „ CHLORINE—*Atacamite, Percylite.*
- (θ) „ CHROMIC ACID—*Vauquelinite.*
- (ι) „ COBALT—*Carollite, Linnaeite.*
- (κ) „ LEAD—*Bournonite, Alisonite.*

- (λ) With PHOSPHORIC ACID—*Turquoise, Libethinite, Thrombolite.*
- (μ) With SELENIUM—*Berzelianite, Encairite.*
- (ν) „ SILICIC ACID—*Dioprase, Chrysocolla, Allophane.*
- (ξ) „ SILVER—*Jalpaite, Polybasite.*
- (ο) „ SULPHUR and IRON—*Copper Glance, Erubescite, Chalcopyrite.*
- (π) With SULPHURIC ACID—*Cyanosite.*
- (ρ) „ VANADIC ACID—*Volborthite.*
- (σ) „ ZINC SILVER, MERCURY, &c.—*Tetrahedrite.*

13. DIDYMIUM. (See CERIUM.)

14. ERBIUM. (a) With YTTRIA—*Orthite, Gadolinite.*

15. FLUORINE. (a) With ALUMINA—*Topaz.*

- (β) With LIME—*Fluor Spar, Aragonite.*
- (γ) „ LITHIA—*Amblygonite, Lepidolite.*
- (δ) „ MAGNESIA—*Wagnerite, Chondrodite, Humite.*
- (ε) „ YTTRIA and CERIA—*Yttrocerite, Parosite.*

16. GLUCINUM. (a) With ALUMINA—*Chrysoberyl.*

- (β) With CHROMIUM—*Emerald.*
- (γ) „ MANGANESE and SULPHUR—*Helvine.*
- (δ) „ SILICA, LIME, and MAGNESIA—*Phenakite.*
- (ε) „ SODA and POTASH—*Leucophane.*
- (ξ) „ TIN and IRON—*Euclase.*
- (η) „ YTTRIA—*Gadolinite.*

17. GOLD. (a) METALLIC—*Native Gold.*

- (β) With ANTIMONY—*Sylvanite.*
- (γ) „ LEAD, COPPER, and SULPHUR—*Nagyagite.*
- (δ) „ PALLADIUM—*Porpezite.*
- (ε) „ RHODIUM—*Rhodium Gold.*
- (ξ) „ TELLURIUM—*Petzite.*

18. IRIDIUM. (a) With OSMIUM, RHODIUM, &c.—*Iridosmine.*

19. IRON. (a) METALLIC METEORITES—*Native with Graphite.*

- (β) With ARSENIC—*Mispickel, Scorodite, Pharmacosiderite.*
- (γ) „ BORIC ACID—*Lagonite.*
- (δ) „ CARBONIC ACID—*Chalybite, Humboldtite.*
- (ε) „ CHLORINE—*Kremersite.*
- (ξ) „ CHROMIUM—*Chrome Iron.*
- (η) „ COPPER—*Chalcopyrite, Boulangerite.*

- (θ) With MAGNESIA—*Magneferrite, Cronstedtite.*
- (ι) „ MANGANESE and ZINC—*Franklinite.*
- (κ) „ OXYGEN—*Magnetite, Hematite, Gothite.*
- (λ) „ NIOBIC ACID—*Columbite.*
- (μ) „ PHOSPHORIC ACID—*Vivianite, Childrenite.*
- (ν) „ SILICA—*Garnet (iron), Nontronite, Anthrosiderite.*
- (ξ) „ SULPHUR—*Pyrite, Chalcopyrite, Kyrosite, Cuperas.*
- (ο) With TANTALIC ACID—*Tantalite.*
- (π) „ TITANIC ACID—*Ilmenite, Kibdelophane.*
- (ρ) „ TUNGSTIC ACID—*Wolframite.*

20. LEAD. (α) With ANTIMONY—*Jamesonite, Boulangerite, Bleinierite.*

- (β) With ARSENIC ACID—*Mimetite, Carmine Spar.*
- (γ) „ CARBONIC ACID—*Cerusite, Tarnowitzite.*
- (δ) „ CHLORINE—*Mendipite, Matlockite, Percylite.*
- (ε) „ CHROMIC ACID—*Melanchroite, Vauquelinite.*
- (ζ) „ COPPER—*Bournonite, Cuproplumbite.*
- (η) „ GOLD and SILVER—*Sylvanite, Nagyagite.*
- (θ) „ LIME—*Plumbocalcite.*
- (ι) „ MOLYBDIC ACID—*Wulfenite.*
- (κ) „ OXYGEN—*Plumbic Ochre, Plattnerite.*
- (λ) „ PHOSPHORIC ACID—*Pyromorphite, Plumboresinitite.*
- (μ) „ SELENIUM—*Clausthalite, Berzelianite.*
- (ν) „ SULPHUR—*Galena, Steinmannite, Caledonite.*
- (ξ) „ TELLURIUM—*Altaite.*
- (ο) „ TUNGSTIC ACID—*Scheelite.*
- (π) „ VANADIC ACID—*Vanadinite, Descloizite.*
- (ρ) „ ZINC—*Zinc-lead Spar.*

21. LITHIUM. (α) With ALUMINA and SILICA—*Spodumen, Petalite.*

- (β) With LIME—*Scapolite.*
- (γ) „ PHOSPHORIC ACID—*Triphylline, Amblygonite.*
- (δ) „ POTASH—*Lepidolite.*

22. MAGNESIUM. (α) With ALUMINA—*Spinel, Pleonaste.*

- (β) With ARSENIC ACID—*Picropharmacolite, Kuhnite.*
- (γ) „ BORIC ACID—*Boracite, Stassfurthite.*
- (δ) „ CARBONIC ACID—*Magnesite, Breunnerite.*
- (ε) „ CHLORINE—*Tachydrite.*

- (f) With FLUORINE—*Chondrodite*.
 - (g) „ CALCIUM—*Dolomite*.
 - (h) „ PHOSPHORIC ACID—*Wagnerite, Lazulite, Sordavelite*.
 - (i) With SILICA—*Talc, Sepiolite, Tourmaline, Serpentine*.
 - (k) „ SULPHUR—*Epsomite, Martinsite*.
23. MANGANESE. (a) With ARSENIC—*Kaneite*.
- (β) With CARBONIC ACID—*Diallogite, Manganocalcite*.
 - (γ) „ OXYGEN—*Pyrolusite, Psilomelane, Hausmanite*.
 - (δ) „ PHOSPHORIC ACID—*Triplite*.
 - (ε) „ SILICA, ALUMINA, GLUCINA, &c.—*Rhodonite, Helvine, Carpholite*.
 - (ζ) With SULPHUR—*Alabandine, Hauerite*.
 - (η) „ TANTALIC and NIOBIC ACID—*Tantalite, Columbite*.
 - (θ) With TUNGSTIC ACID—*Wolframite*.
24. MERCURY. (a) With CHLORINE—*Calomel* (Bavaria).
- (β) With COPPER and SILVER—*Spaniolite*.
 - (γ) „ IODINE—*Coccinite*.
 - (δ) „ SELENIUM—*Onofrite*.
 - (ε) „ SULPHUR—*Cinnabar, Hepatic ditto*.
25. MOLYBDENUM. (a) With LEAD—*Wulfenite*.
- (β) With OXYGEN—*Molybdine*.
 - (γ) „ SULPHUR—*Molybdenite*.
26. NICKEL. (a) With ANTIMONY—*Breithauptite*.
- (β) With ARSENIC—*Copper Nickel, Chloanthite*.
 - (γ) „ BISMUTH—*Grünanite*.
 - (δ) „ CARBONIC ACID—*Emerald Nickel*.
 - (ε) „ COBALT and COPPER—*Cobaltine, Smalltine*.
 - (ζ) „ IRON—*Iron Nickel Pyrites*.
27. NIOBIUM. (a) With IRON, MANGANESE, and TANTALIC ACID—*Columbite*.
28. OSMIUM. (a) With IRIDIUM, RHODIUM, &c.—*Iridosmine*.
29. PLATINUM. (a) With IRIDIUM and COPPER—*Platiniridium*.
30. POTASSIUM. (a) With CHLORINE—*Sylvine, Carnallite*.
- (β) With LIME—*Stilbite, Palagonite, Apophyllite*.
 - (γ) „ MAGNESIA—*Villarsite, Obsidian, Pumice-stone*.

- (δ) With MANGANESE—*Gigantolite, Psilomelane.*
 - (ε) „ NITRIC ACID—*Nitre.*
 - (ξ) „ SILICA—*Orthoclase, Hyalophane, Mica.*
 - (η) „ SODA—*Albite, Endialite, Lava.*
 - (θ) „ SULPHURIC ACID—*Alunite, Polyhalite, Voltaite.*
31. RHODIUM. With IRIDIUM, OSMIUM, &c.—*Iridesmine.*
32. SELENIUM. (α) With LEAD—*Berzelianite, Clausthalite.*
 (β) With MERCURY—*Onobiite.*
 (γ) „ TELLURIUM—*Tetradymite.*
33. SILVER. (α) With ANTIMONY—*Pyrargyrite, Discrasite, Stephanite.*
 (β) With ARSENIC—*Proustite.*
 (γ) „ BISMUTH and LEAD—*Bismuth Silver.*
 (δ) „ BROMINE and IODINE—*Bromyrite, Iodyrite.*
 (ε) „ CHLORINE—*Kerargyrite.*
 (ξ) „ GOLD—*Native Gold.*
 (η) „ MERCURY—*Native Amalgam.*
 (θ) „ SELENIUM—*Ecairite.*
 (ι) „ SULPHUR—*Argentite.*
 (κ) „ TELLURIUM—*Nagyagite, Sylvanite.*
34. SODIUM. (α) With BORIC ACID—*Borax, Hayesine.*
 (β) With CARBONIC ACID—*Natron, Cancrinite.*
 (γ) „ CHLORINE—*Common Salt, Soda, Soda, Alum, Chiolite.*
 (δ) „ FLUORINE and ALUMINA—*Cryolite, Soda, Alum, Chiolite.*
 (ε) With LIME—*Glauberite, Analcime, Gaylussite, Natrolite.*
 (ξ) „ NITRIC ACID—*Nitratine.*
 (η) „ SILICA, IRON, &c.—*Albite, Achmite, Arfvedsonite.*
 (θ) „ SULPHURIC ACID—*Glauberite, Thenardite.*
35. STRONTIUM. (α) With CARBONIC ACID—*Strontianite.*
 (β) With SILICA—*Brewsterite.*
 (γ) „ SULPHUR—*Celestine.*
36. TANTALUM, COLUMBIUM. (α) With LIME—*Pyrochlore.*
 (β) With IRON—*Tantalite, Wolframite, Columbite.*
 (γ) „ YTTRIA—*Yttrotantalite, Lamarskite, Fergusonite.*
 (δ) „ ZIRCONIA—*Wöhlerite, Eukolite.*
37. TELLURIUM. (α) With GOLD and SILVER—*Sylvanite, Nagyagite.*
 (β) With LEAD—*Altaite.*

38. THORIUM. (a) With LIME—*Pyrochlore*.
 (β) With SILICA—*Thorite, Orangite*.
 (γ) „ YTTRIA—*Lamarskite*.
39. TIN. (a) With OXYGEN—*Cassiterite*.
 (β) With SULPHUR—*Stannite*.
40. TITANIUM. (a) With CERIA, &c.—*Mosandrite, Tschevkinitie*.
 (β) With IRON—*Ilmenite, Iserine*.
 (γ) „ LIME—*Schorlomite, Sphene, Perowskite*.
 (δ) „ OXYGEN—*Rutile, Brookite, Anatase*.
 (ε) „ YTTRIA—*Polycrase, Euxenite, Yttrotitanite*.
 (ζ) „ ZIRCONIA—*Eerstedlite*.
41. TUNGSTEN. (a) With IRON—*Wolframite*.
 (β) With LEAD—*Scheelite*.
 (γ) „ LIME—*Scheelite*.
 (δ) „ OXYGEN—*Wolframite*.
 (ε) „ TANTALIC and NIOBIC ACID—*Columbite, Tantalite*.
 (ζ) With YTTRIA—*Lamarskite, Yttrotantalite*.
42. URANIUM. (a) With CARBONIC ACID—*Liebigite, Voglite*.
 (β) With IRON, SILICA, LIME, LEAD, &c.—*Pitchblende*.
 (γ) „ PHOSPHORIC ACID—*Uranite*.
 (δ) „ SILICA—*Uranophane*.
 (ε) „ SULPHURIC ACID—*Trippelite, Johannite*.
43. VANADIUM. (a) With LEAD—*Vanadinite*.
44. YTTRIUM. (a) With SILICA and IRON, &c.—*Gadolinite*.
45. ZINC. (a) With CARBONIC ACID—*Calamine, Aurichalcite*.
 (β) With MANGANESE and IRON—*Franklinite*.
 (γ) „ SILICA—*Smithsonite*.
 (δ) „ SULPHUR—*Sphalerite, Prisbram, Galena*.
46. ZIRCONIA. (a) With SILICA—*Zircon*.

MOLYBDENUM, to detect. (1.) Treat a few pin's-head fragments, one by one, in an HP bead, with O.P. If at first a blue colour results on cooling, but, after further addition, a blue-green, the presence of molybdic acid may be safely predicted, as no other substance produces this

phenomenon—an important fact which will evidently afford quantitative results.

(2.) Heat a paste of the crushed mineral (*Molybdenite*, being in scales, is best filed) on a C. mortar on Al. plate under O.P., allowing the pyrochrome—*yellowish-green*—to impinge on the shining plate. If a yellowish-white sublimate results, which, touched with a momentary H.P. (a continued H.P. turns it black), leaves a *beautiful indigo-blue round spot*, like one of the eyes of a peacock's tail, the sublimate consists chiefly of molybdic acid ; but if, on the contrary, the touched places only turn greenish, as in the case of *Wulfenite*, the sublimate contains MoO₃ in presence of other volatile oxides. The residue after H.P. has the appearance of *copper nickel*. Green p.c.

(3.) "A fragment heated on the bare ledge of Al. plate a long way from the tip of a strong flame affords a *pale-yellow* sublimate which in P.F. is yellower while hot, pale again on cooling ; in R.F. an instant contact produces a splendid blue colour. If the sublimate is slowly brought up from some distance towards the flame, it will be seen to turn blue when still a good way from the blue tip, being rather more sensitive than antimony" (Hutchings).

MORTAR, ANVIL. (See ANVIL MORTAR.)

MORTARS, AGATE. (See AGATE SLABS.)

MORTARS, KEY-HOLE. Made by sawing tablets of charcoal about one-fifth to one-tenth of an inch thick, and cutting these with the grain by a penknife into prisms; two-fifths of an inch broad by half-an-inch long. A shallow hole about one-tenth of an inch in diameter is made in the centre, and the side next the pyrocone cut away with a penknife to admit the point of the O.P. to

the assay, so that the shape of the hole made is that of a keyhole. These mortars (called "charcoal slips" by Hutchings) burn into an angular shape very favourable for the treatment of the assay.

MOUTH-PIECE, BLOWPIPE. Plattner's pattern is too flat for me, so that I had some walnut-wood patterns made in India in 1869, like fig. 11, which I still use; but as these do not pack well, I had some made of gutta-percha by Griffin of Garrick Street, which suit me best of all.

NICKEL, to detect. (1.) *In ores.* Treat the crushed assay under a strong O.P. alone on the bare aluminium plate until there is no longer any smell of sulphurous or arsenious acid; the cake, which generally forms, should be turned over by a penknife, with the unroasted side uppermost, and the operation repeated. The cake is to be then crushed dry between agates, as the addition of water might promote the formation of sulphates—in which the sulphur &c., is not volatilisable—and the powder re-roasted on the aluminium. By this procedure, any nickel present generally appears in the shape of an *apple-green capillary* prot-oxide(?)—a reaction delicate enough to detect 2 per cent. of nickel oxide, as in many specimens of *Cobaltine* or *Smaltine*.

(2.) If, however, this oxide is not thus produced, it must not be thence assumed that no nickel is present, but a trace of the well roasted and mixed powder is to be treated in H.B. under O.P., when *green fragments* are the result, distinguished from those of chromium sesquioxide by assuming a metallic lustre in H.P., and forming a *brown bead* by addition of soda. If the bead is opaque it should be boiled, and cobaltine balls or other borates thus separated, by which Plattner's method of a gold bead on charcoal is

rendered unnecessary. Under a $\frac{1}{4}$ -inch objective, nickel borates appear as *acicular crystals*; chromium fragments as green moss.

(3.) Nickel in alloys may be detected either by lead fuming and subsequent treatment of the sublimate in H.B., or by a bead of H.P. (See ALLOYS, 2.)

NIOBIUM, *to detect*. The mineral *Columbite*, from Had-dam, Connecticut, containing, according to Dana (*Syst. Min.*, 1877), about 80 per cent. of columbic and tanalio acids, 16.4 of iron protoxide, 4.4 of manganese protoxide, 0.5 of tin, and 0.1 of copper, when crushed and lead fumed (see FUMING, LEAD), affords on aluminium plate a greenish-brown sublimate with white border (no yellow) which in H.B. gives a yellow glass, which becomes deeper in tone and gelatinous in cooling. There are also white undissolved fragments like stannic oxide, but too numerous for 0.5 per cent. of that metal. The addition of potash and then of zinc (suggested by Von Kobell's experiment in the wet way) only afforded a diluted yellow. A few specks of the crushed mineral applied *per se* to H.B. yielded bluish-black amorphous fragments with white flocculent matter about them, like those of titanic acid; but unlike those, these fragments have, through a good lens by reflected light, a brilliant semi-metallic brown lustre like *Avanturine*. A pin's-head fragment of pure (egg-shell) lime produced a ball in this bead coloured greenish from iron protoxide, for the avanturine fragments were as yet unattacked. After continued O.P., however, they gradually dissolved in the ball, giving it a fine red-brown colour like that of *Cerite* in H.B., proved to be not due to manganese by its remaining constant in H.P. This *red-brown calciboric ball*,

then, is an infallible test for columbic and tantalic acids in combination, and they seem to be never found separate (*Pyrology*, p. 255).

NITRIC ACID. (See BULBS, GLASS.)

NITROGEN, to detect. (1.) A little of the black part of "weathered" rocks, scraped off and heated in a glass tube closed with the finger, or powder of "stinkstone," &c., thus treated, affords a *smell* like that of *burning fat*.

(2.) Dissolve as much of the powdered assay as possible in an $\ddot{\text{H}}\text{P}$ bead on a clean platinum wire. If nitrogen be present, the bead is *clear* and *colourless* while *hot*, but assumes a *yellow, gelatinous*, or even *horny* appearance *on cooling*, and *the wire is attacked*.

(3.) Dissolve a large trace of manganese binoxide in an $\ddot{\text{H}}\text{P}$ bead by means of H.P., so that the bead remains clear and colourless on cooling. Crush the nitrogenous assay between agates with a little fresh phosphoric acid and treat the mixture in the manganic bead, still with a good blue H.P. The bead will become *amethystine*, and *remain so on cooling*. The same operation often detects chlorine.

OSMIUM, to detect. (1.) In closed glass tube, "osmium tetroxide sublimes in white drops, and has an extremely unpleasant pungent odour" (Landauer).

(2.) "In the oxidising flame compounds give volatile osmium tetroxide, possessing a chlorine-like odour, and attacking the eyes powerfully" (Bunsen).

(3.) Powder of filed *Iridosmine* (which had been fused by the oxyhydrogen blowpipe) was utterly unassailable by O.P. in $\ddot{\text{H}}\text{P}$, even on charcoal, under which conditions platinum is so readily fused. Filings are also unattacked when

fused with lead on charcoal slip over aluminium, which cannot be said of any other known metal.

PALLADIUM, to detect. “On platinum wire, with sodium carbonate in the O.F., compounds are reduced to a grey mass like platinum sponge, which yields silver white, glistening, ductile metallic spangles on grinding in an agate mortar.”—B.

PENS, GEOMETRICAL, as holders. These common implements form cheap and admirable holders for some purposes, as that of dual examination (fig. 29), in which a firmer and more permanent grasp of the platinum wire than that of the ordinary or (s) pliers (fig. 26) is required.

PHOSPHOBORIC ACID REAGENT, to use. (1.) Dip a red-hot bead of H_3B into a concentrated solution of glacial phosphoric acid, made by leaving a small wide-mouthed bottle of the crushed acid open in an ordinary room for a few days, when sufficient moisture is absorbed from the atmosphere to render it fluid. The bead thus made is slightly opalescent on cooling, but sufficiently clear to observe balls, &c., in it through a lens ; if not, it must be vesiculated (see VESICULATION). It is indispensable for the detection of a trifling proportion of lime in presence of silica, alumina, and alkali, as in *Labradorite*. (See ZEOLITIC SILICATES.)

(2.) A kind of pyrological *aqua regia* can be made by fusing about equal quantities of these acids until the resulting bead becomes transparent. It will doubtless eventually prove an important reagent, but I have not had the opportunity yet of trying it much. It serves, however, as a method of detecting boric acid. (See BORIC ACID.)

PHOSPHORIC ACID, examination in. Take up about 2 mgrs. of the powdered substance at bottom of the hot

bead, and apply a momentary O.P. to it. (Manganese is *instantly* detected thus, by forming blood-red bubbles on the bead). If the lens shows no reaction thus, O.P. is to be continued until the substance is dissolved.

The following list, alphabetically arranged, shows the chromatic and other reactions of this powerful solvent:—

Alumina dissolves with some difficulty, appearing in opaque bluish-white fragments like pieces of fat.

Antimony.—A pin's-head fragment effervesces slightly, giving a smell of lucifer matches; when completely dissolved, the bead is intensely yellow hot, and remains topaz-yellow.

Arsenic gives similar reactions, with a garlic smell.

Barium.—No definite reaction.

Bismuth.—Similar to antimony; no smell.

Cadmium.—No definite reaction.

Calcium.—No definite reaction.

Cerium.—Yellow hot; indefinite.

Chromium dissolves with difficulty. The bead is pink hot, yellowish-green cold.

Cobalt.—The bead is blue hot; and with a trace of pink, with 5 per cent. violet, cold.

Copper.—The bead is green hot, green-blue cold in P.P.; green cold in a candle O.P.; dirty-green in sulphurous gas O.P.

Didymium.—The clear bead shows the didymic absorption bands spectroscopically, but it is better examined in boric acid (which see).

Gold.—In a half-inch P.P. the bead, just as it becomes cold, flushes over with a beautiful bluish-violet. In H.P. this bead becomes muddy but bluish.

Iron.—The bead is yellow hot, flesh-colour cold under O.P. A large quantity of oxide gives the bead a brown-red appearance on cooling, like blood in water.

Lanthanum cannot be detected here (see under its head).

Manganese.—A pin's-head speck of the powder taken up on the red-hot bead effervesces, and the bubbles show when cool a blood-red tinge without addition of nitre—a delicate and characteristic reaction. When dissolved and held in P.P., the manganic bead is yellow hot, and about the colour of a pink topaz cold. In H.P. it becomes colourless.

Molybdenum.—The bead under O.P. is yellow hot, and green cold.

Nickel tinges the bead, if added in small quantity, *orange*, if in large, *yellowish-brown*.

Nitrogen.—If unassociated with any colourising metallic oxide, a considerable quantity makes the bead, although colourless hot, yellow and jelly-like cold, and corrodes the wire.

Silver.—The minutest trace affords in O.P. yellowish-creamy streaks, with sometimes (if the assay is rich) a red tinge, so that the whole looks like raspberry-cream. After a little P.P., the streaks dissolve and the bead becomes clear, but if it be suddenly heated for a moment in H.P. (*i.e.*, just *inside* the point of the blue) and withdrawn, a glazed metallic coating is found over the surface, giving the bead *the appearance of a pearl*.

Titanium.—In O.P. the bead is yellow-green hot, amethyst (or purple) cold. In P.P. this bead becomes colourless.

Tungsten.—The bead in O.P. is green hot, blue cold. In P.P. this bead becomes colourless.

Uranium.—The bead in O.P., P.P., or H.P. is yellow hot, pea (yellow) green cold. With the spectrum lorgnette it shows the uranic absorption bands in the green.

Vanadium.—Green, hot and cold in O.P., P.P., or H.P.

(See also different heads.)

PHOSPHORIC ACID, to detect. (1.) Potassium tungstate is made by fusing pure potash by O.P. on clean aluminium plate with pure tungstic acid, adding fresh powdered acid until all effervescence has ceased, and no undissolved particles float in the hot bead. A large quantity may thus be made, broken into pieces the size of a small pea, and kept in a stoppered bottle for use. It should afford only a greyish bead when fused on platinum wire before a long P.P. of good gas. Sulphurous gas appears to cause the bead to be bluish cold; doubtless from the formation of some SO_2 . The phosphatic assay is now dissolved in a bead of pure H₂B by the cautious addition of potash, as too

much would produce potassium phosphate, and spoil the test. A piece of potassium tungstate is now fused upon the phosphatic H_3B bead in a long P.P. (to avoid acquisition of any sulphur from the gas). The bead cools a *bright blue-green* colour, and, with more potash, a *turquoise-blue*. The reaction is based on the fact that tungstic acid affords a blue bead with P. salt, but only yellow with borax. This would appear to be the most delicate test yet known for traces of phosphoric acid. A bead of pure potassium carbonate is first fused upon platinum wire, and as much powdered "rock crystal" or pure silica treated on it before the blowpipe as will form a *clear* bead of potash glass. A small fragment or bead of potassium pyrotungstate is now taken up on the glass bead and treated in P.P. If the silica was pure, and all carbonic acid has been eliminated from the potash, there will be no decided colour, but the combined bead will remain a dull greenish-grey colour. Instead of taking up "rock-crystal," powdered *opal* is now combined with the potash bead and treated as above, when a *brilliant greenish-blue* (*turquoise*) colour results, which can be made more blue by adding potash. In the case of phosphates such as *Coprolite* or *Kunkur*, the powdered assay is first dissolved in a bead of boric acid by cautiously adding traces of potash, which forms sufficient potassium borate to dissolve the lime, &c., leaving the phosphoric acid *free*, when I cannot but believe that some analogous combination to the well-known $12\text{WO}_3\text{K}_8\text{Si}_4\text{O}_6$ is formed, which is *blue*. This test will also detect traces of boric acid *under certain conditions*, which must provide against the formation of alkaline borates; *e.g.*, the use of pure silica as a medium.

(2.) About one-tenth (a pin's-head fragment) in volume of magnesium sulphate—pure *Epsomite* will do—is added to an $\text{H}\ddot{\text{B}}$ bead, and the resulting ball dissipated by the cautious addition of specks of crystallised potassium carbonate; for if too much be added, a flux is formed which dissolves the phosphoric acid. The earthy phosphate now added to this bead is decomposed: the base slowly dissolving, and the phosphoric acid, affording the usual *blue opaline matter*, rendered still more apparent by the further addition of boric acid which, if a considerable quantity of phosphoric acid has been liberated, renders the *whole bead opaque white*. Phosphates with a metallic base, as *Libethinite*, may be treated directly in $\text{H}\ddot{\text{B}}$ under O.P., when a black or dark-brown glaze or lacquer is often formed on the platinum wire; phosphoric acid being liberated as *curdy opaline matter* into the bead, to be determined by cautious solution with potassium carbonate, to clearness and addition of a speck of *Epsomite*, and a large proportion of fresh $\text{H}\ddot{\text{B}}$, which, in the case of phosphoric acid, causes the bead to *become opaline again*. *Pyromorphite* seems an exception to this behaviour, as it forms a *clear ball* in $\text{H}\ddot{\text{B}}$.

(3.) “The powdered substance is placed in a drawn-out glass tube closed at the bottom, and a piece of magnesium wire or a bit of sodium added, and surrounded by the assay. On heating, the mass becomes incandescent, and phosphide of magnesium or sodium is formed. On crushing the tube and moistening its contents with water, the characteristic odour of phosphuretted hydrogen is perceived” (Thénard and Vauquelin).

PHOSPHORIC ACID REAGENT, to use. (Symbol, $\text{H}\ddot{\text{P}}$.)

This invaluable reagent—before the blowpipe the most powerful known acid, oxidising and dissolving gold leaf to a purple bead with ease, and, with addition of charcoal or graphite powder, attacking and fusing platinum itself quite rapidly, affording a brick-red bead apparently of platinum phosphate—is best kept for use, broken up from the sticks in which it is made into fragments the size of a pea, in a small wide-mouthed stoppered bottle. These fragments absorb just sufficient atmospheric moisture to give them an efflorescent covering which, if the bottle be not kept open too long, prevents deliquescence. I have kept a bottle obtained from Messrs. Griffin thus in constant use for four years. As this reagent contains a quantity of superfluous water which must be got rid of on heating, it is best to take up at first a very small fragment on the red-hot platinum ring. When a “glass” of the fused acid has been thus formed on this ring, a large fragment may without fear of its falling be taken up; but it is always best to have a piece of clean aluminium as a tray beneath. Although it at first “smokes” a little as the hygroscopic water evaporates, there is nothing unpleasant or unwholesome in its use; on the contrary, the smell is agreeable, and even tasted the acid is quite harmless, affording another means of recognising some substances. No Carbon or Graphite, &c., should be burned in this reagent supported by platinum, which is then attacked by it.

PLATINUM, to detect. (1.) Fuse a bead of phosphoric acid on charcoal until all effervescence has ceased and it remains quite clear. The white metallic assay, *per se* infusible, which *fuses to a ball* in this flux, and shows *crystalline facets* on the exposed surface, is platinum, while

the bead or slag often has a *brick-red* colour by reflected, and a *bluish* dirty appearance by transmitted light, due apparently to some platinic phosphate. It is a curious fact that pure gold seems unaltered under these circumstances.

(2.) Fuse the *per se* infusible fragment with just sufficient proof lead to enable it to form a ball. Treat this ball in a charcoal mortar on aluminium plate under O.P., and some of the scraped-off sublimate in a glass of phosphoric acid with a half-inch P.P. If the clear glass turns *pale pink*, but muddy with a bluish tint in H.P., platinum is present.

PLATINUM FOIL. Almost every operation to which this support was formerly applied, can be better performed on *aluminium plate* (which see).

PLATINUM FORCEPS or TONGS are chiefly useful in burning off the soot, &c., from dirty platinum jets, by thus holding them in the flame of a spirit-lamp or the base of H.P. The best form is this. For heating fragments

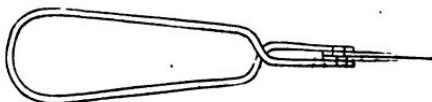


Fig. 35.

of minerals, &c., it is better to bend a thick platinum wire as in figs. 2, 3, 4, into a hook at one end, and to bend the hook again forwards at right angles to the wire, so that the whole may be reversed, and the fragment thus heated in back as well as front by merely turning the wire round. The hook must never be *pressed* upon the fragment, which will then most probably fall out, but,

having been made rather small for the breadth of the latter, an elasticity is retained in the hook, sufficient to hold the fragment. Platinum tongs, as may be easily observed, communicate a strong, constant, orange tint to the blowpipe pyrocone, which renders it advisable to use wire instead.

PLATINUM REAGENT, to use. A ball of platinum (fused on charcoal with a few specks of proof lead) is indispensable for collecting infinitesimal particles of gold from its quartz, or silver from poor ores, and in afterwards detecting those metals on aluminium plate by their sublimes. (See GOLD.) About 40 mgrs. of foil are sufficient.

PLATINUM WIRES, to use. The usual thickness is about .015 inch, or that of a thick horse hair, and the ring made at .5 of the (δ) forceps sustains a bead of the proper size for these operations. To disengage the cold bead, it is only necessary to unroll it from the wire by fixing the thumb nail at the junction of the ring. The crooked wire is then straightened by squeezing it between the flat sides of the (ε) pliers or holder, and cleaned by drawing it rapidly through the same place while it is turned round. The cleaned and straightened wire is then placed with its tip just appearing between the legs of the (δ) or ringing forceps, at .5. The forceps are then turned firmly round until the tip or end meets the side of the wire, when a ring is formed. By having platinum rings thus as nearly as possible round, and of the same diameter, uniformity of treatment is partly secured. The fluid bead then hangs from this ring in the shape of a hand net, and, like the bottom of a miniature test tube, shows all the reactions

going on inside, while the convex surface, when cold, acts as an additional lens in the after examination. "U-shaped loops, which are mainly used," are useless for these important purposes. When it is desired to *flatten* the bead, in order to see colour, &c., through a thinner portion of flux, press the red-hot bead rapidly, but firmly and gently, on clean aluminium plate with both sides, for which purpose the *edge of the ring* must be towards the opening of the pliers, or vesiculate (see VESICULATION). Avoid cleaning wires by dipping them red-hot into hydrochloric acid, which makes them rotten; fusing them into glass tubes, &c., as recommended in many chemical works.

POTASSIUM, to detect. (See also ALKALIES.) (1.) "Potassium is detected in presence of sodium, B.B., by the appearance of reddish-violet through blue glass; of lithium by means of green glass, or the indigo prism (a glass bottle tapering to the bottom, containing indigo solution)" (Landauer). It is, however, far better to employ a spectroscope for compound pyrochromes. (See PYROCHROMES.)

(2.) *In presence of soda.* Fuse a bead of H₂, add two specks (0) of soda under O.P., a little more H₂, and vesiculate (see VESICULATION). The vesicle, breathed on, has a dull watery tarnish, like the appearance of breath on a window-pane. If the assay, now to be added in powder under O.P., contain .1 of potash, the bead, vesiculated and breathed on, shows a *blue opaline cloud*, which, if the vesicle be advanced towards the flame of a spirit-lamp, vanishes, while the similar cloud on a vesicle of pure H₂ remains.

(3.) Dissolve as much as possible of the potassic assay in a bead of H₂, by H.P., and apply the *cold* bead at the

bottom or top of the *base* of a good blue pyrocone. Potash is more volatile than soda, and thus affords a *violet tinge* before the yellow begins. (See BORIC ACID, 3.)

(4.) Mn. solution affords a *deep-toned green* with potash, on Al. plate, but a turquoise-blue with soda. (See SOLUTIONS.)

POTASSIUM CARBONATE REAGENT, *to use*. The crystalline salt is best but decrepitates, which may be “cured” by fusing a fragment, B.B., on aluminium plate with a drop of water. With a little silica on aluminium, it is a far more delicate reagent for sulphur, whether oxidised or not, than soda is (see SULPHUR); also with tungsten trioxide, for *phosphoric acid* (which see).

POTASSIUM SULPHATE ACID REAGENT. This is the (at present) only known way of using sulphuric acid pyrologically. A portion of the powdered assay is heated in a closed glass tube over the base of H.P. along with two or three times its bulk of KHSO_4 , when

Acetic Acid yields a smell of “aromatic vinegar.”

Bromine a reddish-brown vapour.

Carbonic Acid effervesces, whitening lime water.

Fluorine yields a gas corroding glass.

Hydrochloric Acid affords a choking smell of chlorine, forming a cloud over ammonia.

Iodine yields a violet vapour.

Nitrogen yields nitrous red-brown fumes, peculiar odour, increased by copper filings.

Boric and phosphoric acids are also identified by this reagent when mixed with fluor-spar, and supported, B.B., on platinum wire. (See BORIC ACID.)

PYROCHEMICAL MANIPULATION. (See MATERIEL; REAGENTS, under different heads.)



PYROCONES, ARTIFICIAL, are non-luminous blue flames of a conical shape. Those formed by the action of the blowpipe receive their names generally from the position of the subject of analysis, as there is in reality only one pyrocone, the space beyond the apex of which exerts generally oxidising, and that between the apex and base, reducing effects. The term "reducing," however, does not seem to properly apply to some of the effects of the latter-mentioned space, as precipitation, coloration, &c. This space is here therefore called "the hydrocarbonous pyrocone."

Pyrocones are three in number—

- (1.) Peroxidising pyrocone—symbol, P.P.
- (2.) Oxyhydrogen , , O.P.
- (3.) Hydrocarbonous , , H.P.

P.P. is, in fact, the space between 1 and 3 (fig. 36). The point 3 is the best place to obtain the colouring effect of manganese oxide dissolved in a bead of H.P.; the point 2 the best for that of gold. O.P. is the space between a and 1. It is *generally* the hottest part of the pyrocone, and seems to exert about equal effects of oxidation and reduction in a sensitive reagent as phosphoric acid; a substance with great attraction for oxygen, as manganese binoxide for instance, being oxidisable in this space, while most other oxides, as of gold or copper, dissolved clearly in the same reagent by P.P., are here precipitated as a "muddy" bead. H.P. (fig. 38) is any part *inside* the blue; but, in order to produce the best "reducing" effects, the blast should be comparatively feeble, so as to allow the ignited hydrocarbonous matter to collect round the assay in a kind of jacket, as shown in the figure, the point of the pyrocone

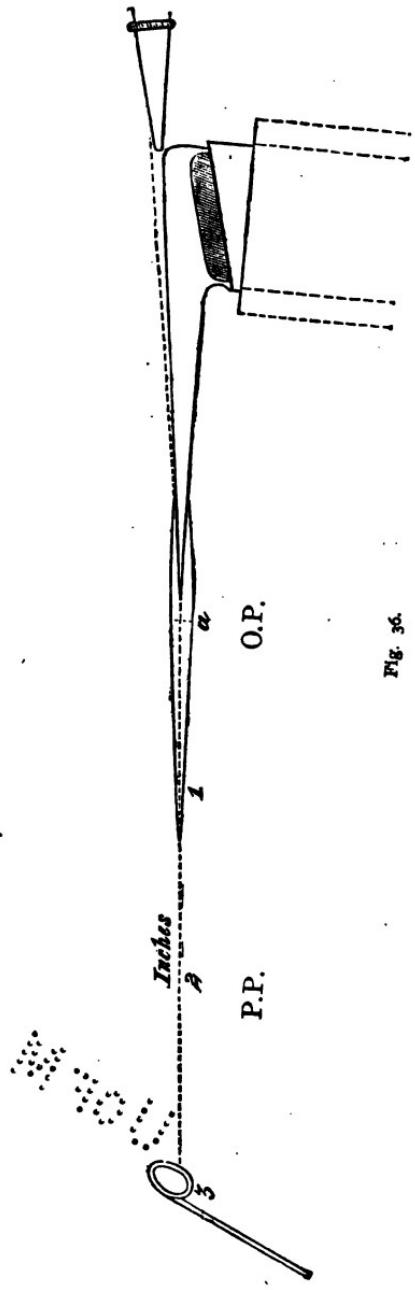


Fig. 36.

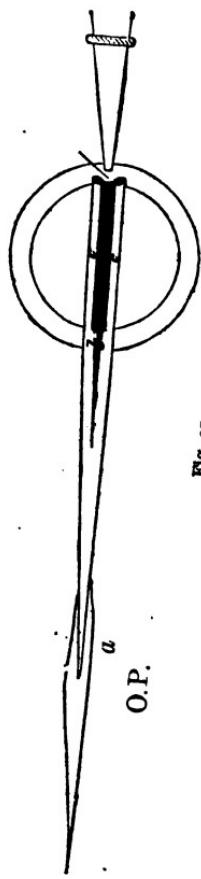


Fig. 37.

rising feebly upwards with a faint luminosity. If this is successfully done, a brilliant metallic-looking film may be thus obtained, and even taken off with tweezers, on the surface of beads, either of H.B. or H.P. H.P. is of great use in obtaining coloured phosphoric acid beads from some oxides, as tungstic and titanic acids; in showing by the non-deposition of soot on fragments, the presence of lime; and in different effects on certain substances, to be found under their respective heads.

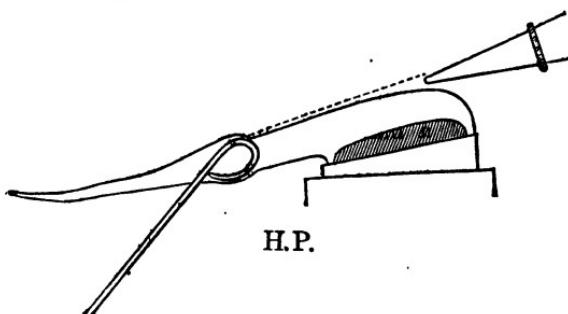


Fig. 38.

PYROCONE, ELLYCHNINE,* to produce. The ordinary pyrocone is made from a candle or lamp, either with a mouth or hand blower; the assay, being at first held in O.P. until thoroughly calcined, is rapidly removed, and, while still hot, the wick is *touched* on one side with the calcined part. When saturated with oil, &c., the coloration effect, which is thrown like a mantle round the whole blue pyrocone, ceases, and the experiment must be performed again. This test is especially useful in the case of calcium silicates, as *Wollastonite*, which scarcely show any pyrochrome in the ordinary way.

* From Ελλυχνίος, the wick of a candle.

PYROCONES, THEORY OF.

If the blast from a mouth blowpipe be propelled by an operator with good eyesight across the heat undulations rising from a lighted candle in broad daylight, by *transmitted* light he will see it (the blast) in the shape of a straight line about the thickness of a fine sewing needle. If, now, he propel a similar blast through the flame of a spirit-lamp, and observe it by *reflected* light, he will again see it, but this time in the form of a minute air-cone synaxial with a flame-cone projected in the same direction from the spirit-lamp. What causes this difference in the appearance of the same thing? The only reply to this question seems to me to be that a confined, continued blast appears to create round it in air, a *vortex*, the gyrative rapidity of which is least at the commencement or greatest *direct* rapidity of the blast, and most when that begins to slacken. This aërial vortex is invisible in air when the blast is passed through the heat-waves above a candle, although the blast itself is perceived there, because a space is formed by it within which the waves themselves are checked; but the air-vortex on the contrary, is distinctly visible when formed within a coloured (blue) fluid of greater consistence than itself, like spirit-flame.

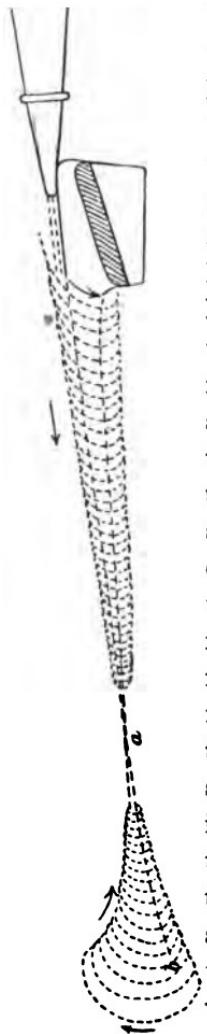


Fig. 39.

of greater consistence than itself, like spirit-flame.

It seems obvious, if this explanation be correct, and the further fact (which can be easily proved) be kept in mind, viz., that the blast from a blowpipe is not really projected *into* the flame as is commonly supposed, but passes *over* it*—that the vortex thus created includes within its gyrations the flame blown on one side in the direction of the blast, and forces it to retain a horizontal position as well as its own conical form. It follows from this that, in order to produce a perfect pyrocone, there should be a constant ratio between the strength of the blast and the size or bulk of the flame acted on; and this is the fact.

PYROCHROME, a coloured flame. (See PYROCONE, ELLYCHNINE; H.P., &c.) Following is an alphabetical list of ordinary pyrochromes :—

<i>Antimony</i>	.	.	.	.	.	Pale-green.
<i>Arsenic</i>	.	.	.	.	.	Faint pale-blue.
<i>Barium</i>	.	.	.	.	.	Yellowish-green.
<i>Boric Acid</i>	.	.	.	.	.	Pea-green.
<i>Calcium</i>	.	.	.	.	.	Red-orange.
<i>Chlorine</i>	.	.	.	.	.	Pale-green.
,, <i>with Copper</i>	.	.	.	.	.	Blue.
<i>Copper</i>	.	.	.	.	.	Bluish-green.
<i>Hydrogen</i>	.	.	.	.	.	Red.†
<i>Lithium</i>	.	.	.	.	.	Blood-red.
<i>Magnesium</i>	.	.	.	.	.	Pink.
<i>Molybdic Acid</i>	.	.	.	.	.	Green.
<i>Phosphoric Acid</i>	.	.	.	.	.	Apple-green.
<i>Potassium</i>	.	.	.	.	.	Violet.
<i>Sodium</i>	.	.	.	.	.	Orange.
<i>Silica</i>	.	.	.	.	.	"
<i>Selenium</i>	.	.	.	.	.	Cornflower-blue.

* Vide *Proc. Roy. Soc.*, vol. xx. p. 451.

† This is best observed by fusing common salt until the air is loaded with HCl, when the blue pyrocone from the blowpipe will assume a red mantle.

<i>Strontium</i>	.	.	.	.	Orange-red.
<i>Thallium</i>	.	.	.	.	Grass-green.
<i>Tellurium</i>	.	.	.	.	Greenish.
<i>Water</i> (chemical as in hydrates)	.				Orange.

PYROLOGY. I proposed this single word as a substitute for the double appellations, "Blowpipe Analysis," "Blowpipe Chemistry," "Dry Chemistry," "Dry Process," &c., &c., not merely because it is evidently more convenient, but also inasmuch as it obviates the necessity of using the ridiculous derivatives obtainable from the latter. English workers in this science, however, seem still to prefer being called "Blowpipers," and their occupation "Blowpiping;" so that I have bowed to the national taste in the title of this work.

QUALITATIVE ANALYSIS OF MINERALS (FREIBERG).

1. *A White Crystalline Powder.*

- (a.) In B.* gives off H_2O , and loses its crystalline form.
- (b.) On Pt. wire melts and tinges the flame green (BaO).
- (c.) Dissolves in borax to a colourless bead, which, when a quantity is present, can be flattened. Pearl-white (not crystalline).
- (d.) Melted with soda on C. and dug out, gives no S. reaction. No reaction for CO_2 with HCl and H_2O .
- (e.) With ($KHSO_4$) in B., got a pale-yellow (Cl.).

The substance is Barium Chloride.

Remarks.—This could have been found in one operation, e.g., holding a mass of the paste on a Pt. ring, in a candle

* The letter B. represents a glass bulb, or closed test tube; C., charcoal. The unknown substances were given to students by Professor Richter of Freiberg.—*Hustler's Notes.*

H.P., when a roundish *black patch* (chloride of C.?) is formed in front, and the pyrocone tinged with green in rear, which reaction denotes *Barium*. For confirmation of *Chlorine* (see that head), presence of barium confirmed by treatment in H_2B .

2. Transparent Crystals.

- (a.) In B. gives off much H_2O , changes colour, and sticks to the glass.
- (b.) On C. intumesces, remains outside, glowing with a bright light, while hot; moistened with Co. solution in O.F. turns *pink* (MgO .).
- (c.) On silver foil gives S. reaction.

Substance is magnesic sulphate.

Remarks.—A pin's-head fragment treated with O.P. in an H_2B bead effervesces (either CO_2 or SO_2), and finally gives a *white opaque* ball (MgO .). Another piece, heated in H.P. on Al. plate and quenched with water, smells of H.S., and if soda be added, turns salmon colour (see SULPHUR), showing that the combined acid is sulphuric.

3. A White Powder.

- (a.) In B. gives off no H_2O .
- (b.) On Pt. wire or in forceps, lighted strongly, tinged the flame reddish, and did not melt (CaO .).
- (c.) Gave the S. reaction.

Substance is anhydrous Gypsum.

Remarks.—As in 2 remarks, the *clear* ball showing lime instead of magnesia. Confirm the presence of lime by E.P.

4. A Greenish-black Powder.

(a.) Dissolved in borax, gave a pure green colour ; thought Cu. was present, so knocked off the bead and reduced it on C., when it was red from Cu_2O . Got the Cu. together and redissolved the remainder of the bead in more borax, having first pressed it abroad. The reaction in O.F. was yellow hot and yellow-green cold, showing the presence of Cr_2O_3 .

Substance was a mixture of CuO . and Cr_2O_3 .

Remarks.—One operation shows these results. Treat a trace of the powder in HB under O.P. The blue-green pyrochrome and indigo balls show oxide of copper ; the green amorphous fragments, Cr_2O_3 .

N.B.—All mechanical mixtures at once separate in HB, chemical combinations are not quite so easily detected.

5. A Brownish-black Powder.

(a.) Dissolved in borax, gave a beautiful reddish-blue, showing the presence of CoO. The red colour, however, indicating the presence of another metal, tried it with soda and saltpetre on Pt. foil and got the blue colour of Mn.

Substance was CoO and MnO_2 .

Remarks.—By the application of a few specks of the powder to HB and treatment with O.P., MnO_2 forms black vitreous balls, becoming transparent and brown in P.P. ; while CoO forms violet balls, and the MnO_2 balls become clear and colourless in H.P.

6. A Brown Mineral.

(a.) In B. decrepitates, giving off little or no H_2O ; changes to a grey colour.

(b.) In Pt. forceps melts and gives a green colour to O.F. (pres. of BaO.).

(c.) Gives no sublimate on C.

(d.) With soda on C., greatest part sinks in, but a portion of white remains in the year rings (pres. of CaO.).

(e.) The remains dug out of the C. and put on silver plate with H₂O, give reaction for S.

Mineral is Barite, with trace of lime.

Remarks.—Detected in one operation, the paste on a Pt. ring in a candle O.P. shows the yellow-green of barium compounds; then, when advanced so as to touch the wick, as in E.P., the red-orange pyrochrome of lime; a drop of water on the hot mass gives a strong rotten-egg smell (H.S.), but the pres. of sulphuric acid should be confirmed with H₂B (effervescence) and then with soda on aluminium plate.

7. A White Chalky Mineral.

(a.) In B. gives off H₂O., which has an acid reaction. No decided reaction in the forceps; does not melt; no sublimate on C.

(b.) With Co. solution in O.F. becomes blue (Al₂O₃).

(c.) With soda on C. substance remains outside.

(d.) The C. dug out, wetted on Ag. foil, gives S. reaction.

(e.) It is soluble in HCl.

Substance is Aluminite.

Remarks.—There is no potash in *Aluminite*, from which the other similar mineral (*Alunite*) is easily distinguished. A fragment on an aluminium spoon in O.P. glows, showing it to be an "earth." In H.P. it blackens rapidly, showing,

it is not one of the "alkaline earths." The blue from a drop of Co. solution in O.P. shows it to be chiefly alumina, and the smell of H.S. while applying the solution, shows the presence of sulphur; confirm that as in the preceding.

8. *A Mineral like Fossilised Cocoanut "Meat."*

- (a.) Does not change in B. and gives off little H₂O.
- (b.) In forceps melts easily to a ball, colouring O.F. red-dish-yellow (soda).
- (c.) On C. gives no sublimate but melts to a clear bead, opaque when cold, which spreads out and part sinks into the C.
- (d.) With Co. solution becomes *blue* (Al₂O₃).
- (e.) No action for S. on Ag. foil; none for CO₂ with HCl. dil. No action in B. for Cl., Br., or I., so tried it with P. salt in open tube, and got the Fl. reaction; also tried it with HSO₄ in porcelain cup on glass, and got a first-rate reaction for Fl.

Decide the substance to be fluoride of sodium and aluminium, or Cryolite.

Remarks.—On an Al. spoon, the substance melting to a *clear* bead hot and opaque-white cold, shows it to contain at least 25 per cent. of an alkali, which by the intense orange pyrochrome is seen to be soda. The paste in a candle H.P. gives a dark-grey round patch in front (with a very pure H.P., as that obtainable at 7000 feet elevation, this patch becomes *green*, but cannot be made so in England)—chlorine or fluorine—confirm by the suffocating *smell* of a trace heated in O.P. on H₂B, or by the beautiful blue colour given by it to an H₂P bead coloured *green* with

CuO. in a candle H.P. Basic alumina is detected by the pure blue given with Co. solution under O.P.

9. A Black Mineral, with Metallic Lustre.

- (a.) Is not magnetic before roasting nor after. Decrepitates in B. but gives off no H_2O .
- (b.) Gives no sublimate on C. and no smell of SO_2 or As.
- (c.) With borax gives a reddish bead cold, as also with P. salt.
- (d.) Is slightly soluble in HCl. and gives a blue colour with potassium ferrocyanide (Fe_2O_3).
- (e.) Heated with HSO_4 , a blue fluid is obtained.
- (f.) Melts to a slag with soda, and is slightly fusible on the edges.

Substance is Wolfram.

Remarks.—In an HB bead under O.P., a few specks of the powder would give—(a) *black-blue amorphous particles* (WO_3) ; (b) black vitreous balls, becoming clear and brown in O.P. (MnO_3) ; (c) *rusty-brown opaque balls* (Fe_2O_3) ; and if some fresh powder be treated in an HP bead, the characteristic beautiful *blue* of tungstic acid at once appears when treated with H.P. and disappears in P.P.

10. A White Crystalline Substance.

- (a.) In B. gives off a white vapour which settles on the sides of the bulb; and turns yellow while hot. In the forceps, gives a lot of white smoke.
- (b.) On C. is melted, and gives off copious white fumes, which settle on the C. and are very volatile.

(c.) With soda in B. gives off a substance which settles on the side and forms a mirror ; when rubbed forms globules (Hg.).

(d.) With CuO. on C. gives a beautiful blue flame striped green (presence of Cl.).

The substance is therefore HgCl. or Cl₂.

Remarks.—Calomel on C. under O.P. sublimes *at once* ; corrosive sublimate *fuses first* and then sublimes. This must therefore have been the latter (HgCl₂). Heated in a gentle O.P. on aluminium plate, a vapour arises from this salt which has the *choking smell* of chlorine ; while a thin white sublimate remains high up the plate, which, scraped with a penknife, congests into globules of Hg. The mercurial rainbow is also afforded on the plate by strong O.P., but the plate may then be attacked.

11. A Substance with Metallic Glance.

(a.) In B. gives no H₂O., and does not change. In forceps, melts slightly on the edges. Gives no sublimate on C.

(b.) In O.F. in borax, gives the Mn. reaction, and in R.F. reactions for Fe.

(c.) In P. salt, O.F. gives the Fe. reaction, as Mn. does not colour the bead so strongly in P. salt as in borax.

(d.) In the R.F. got a red bead, which showed that either TiO₂ or WO₃ was there ; but titanic Fe. does not melt in the forceps ; this did, so the mineral is *Manganese Wolfram*.

Remarks.—*Vide* remarks under (9), by the procedure de-

tailed in which these constituents would be detected, in one operation. The distinction between TiO_2 and WO_3 would have been best obtained by fusion of the assay with lead; and treatment of the sublimate in H_2S . (See TITANIUM.)

12. The Substance is Yellow with a Crystalline Structure.

- (a.) In B. decrepitates and changes colour a little, but gives off no H_2O .
- (b.) On C. gives a smell of As., and a smoke which settles as a sublimate some distance off, while nearer the assay there is a yellow sublimate of PbO , and a globule of Pb. is left behind.
- (c.) With CuO . on C., it shows a trace of Cl.

Arsenite of lead or Mimetite.

Remarks.—According to authorities cited by Dana, *Mimetite* has 9 per cent. of plumbic chloride, which should show more than a trace. There appears also to be in most varieties a considerable quantity of phosphoric acid, and often lime replacing the PbO . An attempt should have been made to detect these; Al. plate would have been the best support for this assay.

13. Substance is of a Grey Colour with Glassy Lustre.

- (a.) In B. melts, giving off no H_2O .
- (b.) On C. melts, affording first a yellow sublimate of Pb., and outside a thick white one, which is pretty volatile. With $KO\bar{O}$. it is quickly reduced to a globule of Pb.
- (c.) In B. with soda gives no smell, and nothing is deposited on the tube.

(d.) In the open tube gives off a white sublimate, which, treated before the blowpipe, aggregates into drops of an opaque-white or a grey colour.

(e.) With CuO. gives a strong Cl reaction.

I therefore suppose the substance to be PbCl.

Remarks.—An unsatisfactory assay, of which the operator seems aware, as his conclusion expresses doubts. The drops mentioned in (d) indicate the presence of some oxide not determined. I have seen *Antimony* sublime thus on steel, and the white sublimate (b) suggests the presence of that metal or of bismuth.

14. *The Substance is a Yellow Powder.*

(a) In B. changes to a liver colour, and gives off H₂O. On C. no sublimate, and with soda or KO₂. is not reduced to metal, but makes a sort of slag.

(b.) In O.F. in borax is yellow cold; in R.F., yellow with green tinge.

(c.) In O.F. in P. salt, the bead is greenish-yellow; in R.F., emerald-green.

(d.) The borax bead with zinc on C. becomes green.

Substance is, therefore, oxide of Uranium.

Remarks.—Uranic beads or glasses made with any description of flux are best distinguished from the green of chromic or molybdic acid by the *absorption bands* observed with the spectroscope. (See URANIUM.)

15. *A Green Waxy Substance.*

(a.) In B. decrepitates and gives off no H₂O.

(b.) In forceps melts easily, colouring the outer flame blue.

(c.) On C. melts to a white *crystalline* bead, and with KO₂ gives a bead of lead.

(d.) Mixed with CuO. in O.F. on C. gives a strong reaction for Cl.

Substance is Pyromorphite.

Remarks.—It should have been mentioned that the word *crystalline* indicates phosphoric acid. It is a curious fact that *Pyromorphite* affords a clear colourless *ball* in H.B under O.P.

16. *A Reddish Mineral with Metallic Glance.*

(a.) In B. does not give off H₂O, and does not decrepitate. In forceps, infusible.

(b.) On C. gives no sublimate; with soda melts to a reddish bead.

(c.) In borax in O.F. gives the Fe. reaction; and in R.F. the colour goes away, or nearly so.

(d.) In P. salt in O.F. gives a colourless bead; in R.F., a beautiful violet colour.

The mineral is Rutile.

Remarks.—Detected in one operation in H.B under O.P., when the iron brown opaque *balls*, and the titanic grey-blue fragments are separately visible; if a lime-borate ball be now formed in the bead, it will become purple in H.P., and colourless in P.P., showing the TiO₂.

17. *A Yellow Earthy-looking Substance.*

(a.) In B. changes colour a little; on C. got a sublimate of Pb., the assay melted, and there was a trace of a lighter sublimate in the distance.

(b.) To see what was with the lead, added a little borax glass to the slag left on the C., and treated to O.F., when a green bead was produced. This could only be Cr_2O_3 or VO_3 . To prove which it was, treated some of the original ore to O.F. in P. salt, when it was coloured green.

Substance is Crocoisite.

N.B.—All the lead earths can be tried by melting in a platinum spoon with KHSO_4 ; in which case Cr_2O_3 separates and is violet, VO_3 orange-yellow, while P_2O_5 lead will in that case remain a white mass of salt.

Remarks.—Could have been detected in one operation in B., with the further addition of soda. (See VANADIUM and CHROMIUM.)

18. *A Yellow Earthy Substance.*

(a.) In B. decrepitates forcibly; gives off H_2O . On C. got no sublimate but that of Pb. with a few metallic beads of lead.

(b.) Then tried it with borax glass when I got a dirty colour, so tried it in a bead of borax and reduced it on C., when a black bead was produced with some white in it from the lead oxide, which spoke of the presence of MO_3 .

(c.) To prove this, dissolved some of the powder in P. salt, and got in O.F. a green colour, which, with the other reaction, proved the presence of MO_3 .

(d.) Then dissolved some of the mineral in KHSO_4 , diluted with H_2O_4 , and added a piece of zinc, when I got a blue colour by the formation of a lower oxide from the MO_3 .

The substance is Molybdanochre.

Remarks.—If no reaction is given on aluminium plate (see MOLYBDENUM) for molybdic acid, it will, if present, still be detected in H₃B as insoluble *black fragments*, which potassic carbonate dissolves, without giving chromatic effects. Conclusive evidence is then afforded by H₃P, which gives a *blue-green bead* with MO₃.

19. A Brown Mineral, with Metallic or Resinous Glance.

- (a.) In B. decrepitates feebly; gives off no H₂O.
- (b.) On C. gives a white sublimate, which is not volatile and which, with Co. solution, gives a bluish-green colour. In the forceps it does not melt, but a white efflorescence comes out upon it.
- (c.) In O.F. with soda melts to a slag; but in R.F. with KO₂, got a bead of white metal which was malleable.

The substance is therefore Cassiterite.

Remarks.—The reaction (b) was sufficient to have determined this mineral. It is best performed on aluminium plate, where, under O.P., a fragment of *Cassiterite* also sweats out metallic balls (see TIN). There was most probably iron, and perhaps tantalic acid in this mineral (see those heads for their detection).

20. A Black Mineral with Metallic Glance.

- (a.) Infusible. Is magnetic after roasting in R.F.; dissolves with difficulty in HCl. with smell of Cl.
- (b.) In borax gives Mn. and Fe. reactions; in P. salt, the same.
- (c.) On Pt. foil with saltpetre and soda, gives a strong Mn. reaction.

(d.) With soda on C. in R.F. gives a faint reaction for Zn.

So the mineral must be Franklinite.

Remarks.—Heated on Al. plate in O.P., this mineral affords a white sublimate which becomes yellowish in O.P. (zinc). A coffee-brown efflorescence is observed on the off side (MnO_2), and the fragment is left magnetic (iron). Confirmatory tests : HB ; HB with addition of baryta (Mn. coloration) ; soda on Al. plate (for Mn. and Fe.) ; and in H.P. a woolly matter (Zn.).

The following is an illustration of modern qualitative blowpipe analysis :—

*An Apple-green, Crystallised, Semi-transparent Mineral
from Spain.*

- (1.) Crushed to fine dust between agates, a few specks }
are unattacked in HB by }
strongest O.P. }
(a.) Might have been *silica*, but
quartz easily scratches this
mineral.
- (2.) Fused (1) with K_2CO_3 on }
Al. plate, and boiled the }
mass in water. }
(a.) A greyish-white residue.
- (3.) In HB O.P. the dried residue (2a) now afforded— }
(a.) *White opaque balls* unclarified by strong O.P. (Distinguished from magnesio-
um borate.)
- (4.) Remainder of (2a) dissolved by specks of K_2CO_3 in }
HB bead (3a). }
(a.) A transparent colourless
bead.
- (5.) Treated (4a) with potassium pyrotungstate. (See }
PHOSPHORIC ACID.) }
(a.) *Turquoise-blue opaque bead*
both after H.P. and P.P.
- (6.) Powder (1) heated with }
crystals of H.P. in test tube }
over base of pyrocone. }
(a.) Part dissolved ; slight
fumes ; glass strongly at-
tacked.
- (7.) Paste of powder (1) on plati- }
num wire, in candle H.P. }
(a.) A black round spot in front
of white mass.
(b.) On copper wire gives a blue
pyrochrome.

Remarks.—These seven operations will be found to

occupy altogether about twenty minutes, and they prove, by—

- (3a.) That *lime* is the chief base ; by
- (5a) That the acid is *phosphoric* ; by
- (6a.) That the mineral also contains *fluorine* ; and by
- (7a and b.) The presence of *chlorine*.

The bead (5a) remaining blue after H.P. shows over 5 per cent. of phosphoric acid ; and the *opaque white* balls of (3a) indicating phosphate of calcium after fusion with potash and decantation—that there is a *large proportion* of phosphoric acid. The mineral, therefore, is obviously CRYSTALLISED APATITE.

RHODIUM, *to detect*. These rare metals are so seldom met with that their detection possesses little interest. Infusibility before O.P. in $\ddot{\text{H}}\text{P}$ on charcoal distinguishes them from platinum. (See OSMIUM and PALLADIUM.)

SALTS, *to detect constituents of*. Very delicate reactions, useful for detecting *traces* of oxides in minerals and other complicated compounds, often fail when applied for this purpose to laboratory salts. The pyrologist must exercise his own ingenuity in such easy operations. For instance, to detect phosphoric acid in microcosmic salt, he would simply apply, B.B., a little tungstic acid.

SAWS, THREAD. Several should be kept for making charcoal mortars ; can be held in a geometrical pen.

SELENIUM, *to detect*. The following are the reactions of Tilkerode *Clausthalite* on bare aluminium plate :—

- (a.) A brownish-black, velvety halo surmounted by white sublimate turning black *instantaneously* in O.P.
- (b.) Above the white a broadly-spread thin, semi-metallic-looking, copper-coloured sublimate, turning *bronze* in O.P.

(c.) Bright blue pyrochrome with smell of rotten horse-radish.

(d.) On wiping away (a) with a silk cloth a bright brick-red stain was found under the fragment, which turned bronze in O.P. with blue pyrochrome.

(e.) The assay only partly fused (diff. from tellurium).

(f.) No sublimate on steel forceps (diff. from bismuth).



Fig. 40.

SIEVE, BRASS, for filtering minerals, like *Jeypoorite* (fig. 40).

SILICA, to detect. (1.)

Take up a trace of the fine powder on an HB bead.

If it is utterly infusible and unaltered by the strongest O.P., but affords a *water-gruelly dimness* to the bead on the addition, B.B., of a calcium-borate ball, with *acicular crystals on the ball* like the marks on "graphic granite," silica is present unaccompanied by alumina, which in this case turns the whole bead opaque milk-white (see ALUMINA). To detect the silica, then, the bead is dissolved in boiling water, and the ball added to a fresh HB bead, when the above-mentioned crystals will be observed through a good lens still adhering to it. As silica, though in the finest powder, is utterly unattacked in HB, and soluble afterwards, in proportion to soda added B.B., this method not only forms the best to distinguish it, but would be a good plan with a view to quantitative estimation.

(2.) Over 5 per cent. of silica can be recognised where no alkalies are present, by treating the fine powder in a bead of microcosmic salt, in which, after so much has been

dissolved, the rest remains behind as a semi-transparent mass called a "skeleton," best seen by transmitted light. (For the analysis of complicated silicates, see ZEOLITIC SILICATES.)

SILVER, *to detect.* (1.) If the ore be siliceous, the metallic part should be collected with a ball of pure copper, and about 10 mgrs. proof lead treated in a quantity of the powder proportional to the supposed poverty or richness of the ore, under O.P., in a hole in charcoal with sufficient reducing flux to make a good fluid slag (see GOLD), but if free from gangue, a few specks of the proof lead will alone be sufficient, and if the non-siliceous ore contain lead or antimony, even this may be dispensed with. The alloy-ball is now cleaned from all particles of slag by gently squeezing it with the (α) forceps, and treated *per se* in charcoal slip on aluminium plate. A *pink tinge* in the resulting white sublimate shows the presence of silver, which must not be confounded with the brick-red of per-oxydised lead, which is sometimes formed, but which has no violet in it. Hutchings tells us (*Chem. News*, vol. xxxvi. p. 218) that he failed to obtain this reaction with quartzose silver ores, which failure seems to have occurred because he did not separate all metal by means of a metallic ball in the first place.

(2.) In confirmation of the above, the pink sublimate is scraped gently and carefully off the aluminium plate with a smooth-edged penknife, placed on an agate, taken up at bottom of an H^P bead and treated with O.P. Plumb-argentie sublimate thus presents streaks or "flecks" of yellow-creamy matter, bluish by transmitted light. By H.P. a dense, opaque, tortoiseshell-red yellow precipitate

is produced, which is also characteristic, but the most beautiful and certain test is produced as follows.

(3.) The argentiferous bead is clarified by P.P., and then momentarily plunged into H.P. (near the tip of the blue). A thin superficial film of silver is thus apparently produced near the surface of the bead, but covered with a vitreous coating of phosphoric acid, which imparts to the whole bead an almost perfect representation of a *pearl*. A little practice is required to produce this pleasing illusion, but that is soon acquired.

(4.) Supported on an aluminium spoon and a strong O.P. applied to an edge, pure silver does not fuse except on the edge, which as it burns affords a *reddish-orange pyrochrome, pink* if only partly produced, like the colour of the "ruby sublimate."

(5.) *Cupellation.* This process may do until a better has been devised, for the *estimation* of silver in ores, but it seems absurd to resort to it for the *detection* by the blow-pipe of small quantities of such a volatile metal as silver. (See GOLD.)

(6.) To distinguish from gold, which also affords a violet sublimate of the same tint, a plumbo-platinic ball is used instead of the copper one above mentioned (1), when the *bona fide* silver sublimate will be afforded on aluminium. It is of a golden-bronze colour, and so thin that it appears semi-metallic spread over the polished aluminium, but may be scraped off as a brown powder, and gives argentic reactions in H.P. without any rose tint. From this fact, it would appear that the violet sublimate obtained from silver is, in reality, due to contained gold.

SILVER FOIL as a reagent. Is used for detecting

sulphur, selenium, and tellurium (see SULPHUR). It is very handy to pyrelectroplate the back of one of your aluminium plates with silver instead of carrying about silver foil for this one reaction. It is thus performed : Some crystals of silver nitrate are powdered between agates, and made into a paste with a few drops of water ; this paste is then thinly but evenly laid on the part of the Al. plate which it is desired to silver, and treated with a gentle O.P., when a fine and strong silver-plating is obtained. Another coating of the paste will make it thicker if desired. I have used a silvered aluminium plate thus made, in the detection of sulphides, &c., for four years, and it is as good as ever now.

SODIUM, to detect. The difficulty of proving the presence of sodium in minerals, &c., seems paradoxical, as it arises from the "fatal facility" with which its orange pyrochrome, exhibiting "D" lines spectroscopically, is produced by almost every inorganic substance when strongly heated in O.P. A fragment of calcium or magnesium carbonate, judging from its strong orange pyrochrome, in O.P. would at first appear to be full of soda, but the "yellow flame" ceases entirely when either fragment has lost its carbonic acid. The following letter, published in *Nature* of 7th March 1876 (vol. xiii. p. 366), seems to me to prove conclusively that, in one of these cases at all events, the production of "D" lines is not due to sodium :—

"1. If platinum wire be reddened from a constant source of heat as that applied to it by means of a blowpipe and a candle, we find the D-line spectra indefinitely produced until incandescence takes place by *additional* heat, or in other words, that their permanency is in direct proportion to the *bulk* of the wire

used, and in inverse proportion to the amount of heat applied. We can therefore, by using a *thick* platinum wire and the ordinary flame of a blowpipe, produce D-line spectra as long as we like, or as long as the fuel lasts.

"2. Now, if this D-line producing flame be due to sodium, its action for a long period upon a reagent so sensitive to sodium as is *boric acid*, ought to give a reaction by which the presence of that alkali would be detected. Thus, if a pin's-head speck of pure cobalt oxide be heated by a blowpipe in a bead of pure boric acid, it forms within it a *black ball* which the minutest trace of any *sodium salt* partially dissipates, causing a *pink suffusion* round the ball.

"3. A boric acid bead fused upon the ring of a thin or ordinary platinum wire, which has previously been made incandescent by a blowpipe flame—*i.e.*, from which the D-line producing property has been previously removed—is clear, colourless, and refractive as a diamond; but if the same boric acid be fused upon a *thick* platinum wire with the same degree of heat, the bead is *opaline* and *almost opaque*; and this phenomenon seems evidently and only referable to the above-mentioned permanency of the D-line spectra produced in the latter case.

"4. To settle this point, however, let us fuse a clear colourless bead of boric acid on an ordinary platinum wire, and screw that in a geometrical pen, along with a *thick* platinum wire, so that the D-line producing flame from the thick, hot wire, impinges constantly and for some time upon the clear boric acid bead; we find opacity produced as in the former case. Now, supposing sodium to be in this case the producer of the D-line spectra, we ought to have, in the opalised boric acid, a tangible result of the effect of applying to it, according to Professor Stokes, 'free sodium,' but on heating in it, as before, a speck of cobalt oxide, there is *no* dissipation of any part of the resulting ball, nor the least pink suffusion, but, on the contrary, a reaction, decided indeed, but *almost exactly* the opposite of that caused by adding sodium to the bead in any proportion.

"5. Let us now screw a platinum wire ring containing a boric acid bead with a cobalt-borate ball inside, into a geometrical pen behind another platinum ring containing a bead of some soda salt, and heat both together with a blowpipe, so that the orange flame from the latter impinges upon the former. Instead of opalescence,

similar to that caused by the orange flame from the thick platinum (4), we find the viscid boric acid made *more fluid and clear*, the cobalt-borate ball partly dissipated, and, on cooling, the surface of the bead presenting a pink appearance, evidently caused by projected particles of soda, volatilised *per se*.

"6. It would thus seem that the blowpipe is even a more delicate analytical weapon than the spectroscope, for it distinguishes between two flames exhibiting D-line spectra only, which spectrum analysis does not.

"W. A. Ross."

Some contrivance, therefore, is necessary, by which this very delicate indication may be so utilised so as to detect soda only when it is really present. Such an effect is admirably rendered by the green pyrochrome of boric acid. The most trifling proportion of soda, really contained in a mineral or other complicated compound, added in powder, B.B., to a bead of H_2B , *orangises the normal green pyrochrome*, which nothing else except phosphoric acid seems to do. About 2 per cent. of soda will render the green pyrochrome of a large bead *wholly orange*. Potash heightens the colour; lithia renders it violet.

SODIUM CARBONATE REAGENT, to use. Ordinary "soda" from a druggist's shop will answer well, but it is more convenient to fuse this in a platinum spoon before O.P., after which, broken into fragments the size of a small pea, it keeps better and obtains reactions much quicker. It is best supported on aluminium plate, where it not only forms a "bead" or ball, instead of a pool as on platinum foil, or of sinking into and taking up all kinds of matters from charcoal—but it can be "oxidised" and "reduced" on this support just as easily as a bead of H_2B . In testing for sulphur with soda, coal-gas must not be used, as it invariably produces a pink bead, but a candle or

lamp, in the H.P. of which it should be tested on Al. plate, when the resulting bead should cool *white* inside and out. It is a curious fact that soda, potash, and lithia, when lead fumed, afford *balls* in H.B. (see *Pyrology*, pp. 206, 207), but I have not had time, opportunity, or encouragement yet to utilise this interesting fact. (For the various uses of soda, see different heads.)

SODIUM TUNGSTATE REAGENT. (See PHOSPHORIC ACID.)

SOLUTIONS, REACTIONARY. (1.) *Cobalt.* The nitrate is best, and should be as dilute as possible, because CoO. in any quantity seems reduced even by O.P. in presence of most substances to a black or grey mass, and thus spoils its reactions: It is applied in two ways—(a) dropped on the mineral or assay *after* that has been well heated by O.P.; (b) by applying an O.P., or better a P.P., to (a). In the first case, the whole of the “earths,” with the exception of *lime* and *strontia*, are merely made pink by absorption of the solution; these two, however, turn *blue* thus treated, of deeper tone in proportion to their quantity and therefore causticity. After a short exposure to the air, the blue lime fragments turn *green* on the outside, the inside remaining white. Strontia blue turns *brown*. This important reaction has escaped all writers on the blowpipe. In the case of (b) application, the following tabular view of reactions is from Plattner (4th ed.) :—

Brownish-red. Baryta.

Flesh colour . Magnesia, Tantalic Acid.

Violet . . Zirconia, Phosphate and Arsenate of Magnesia
—fuse at same time.

Blue Alumina, Silica.*

Green Oxide of Zinc, Titanic Acid (*yellowish-green*),
Oxide of Tin (*bluish-green*).

(2.) *Manganese* (sulphate). The solution should be heated, after application, in O.P., which however should be directed only on one part of the fragment, when the characteristic colour will be found on the other side. As the great object in applying all such solutions is to avoid reduction, they are better applied on an aluminium spoon than on charcoal when a decrepitating fragment compels the use of powder. The following is a list of some of the chromatic reactions of Mn. solution :—

<i>Potash</i> (pure)	A deep-toned blue-green.
<i>Soda</i>	Green-blue (<i>turquoise</i>).
,, with alumina as in <i>Cryolite</i> .	Brown.
<i>Baryta</i>	Yellowish-green.
<i>Alumina</i> (pure)	Drab-yellow.
,, with soda	Brown.
<i>Magnesia</i>	Salmon-pink.
<i>Silica</i>	Remains white.

SPECTRUM LORGNETTE is a small spectroscope at-

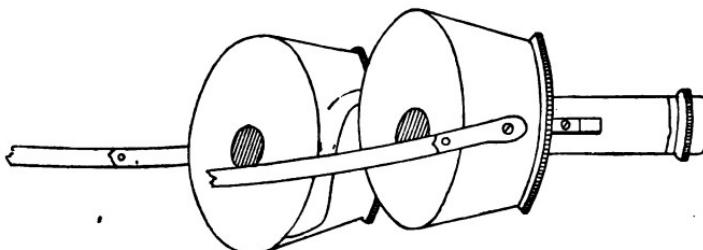


Fig. 41.

tached to the head like spectacles, so that the operator

In my experience SiO_2 thus treated affords a violet colour.

can synchronously note the spectra of pyrocones or pyrochromes, while he is producing them; as also absorption bands (see BANDS, ABSORPTION). It is composed of two barrels or spectacles made of blackened brass, looped together by two padded bridges of brass, one of which fits the nose. The bore of the other barrel is left unoccupied, to enable the operator to see through it what he is about.

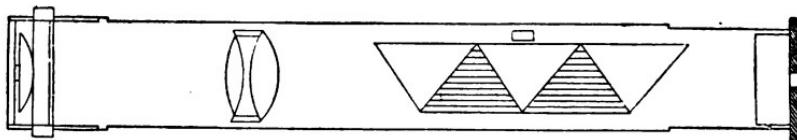


Fig. 42.

The figure 41 represents a pair of spectracles made for me by Mr. Browning, the celebrated English optician; and fig. 42 his "minute spectroscope," only 1.7 inch long, made specially for this apparatus.

SPECTRUM LINES, *table of.* (See opposite page.)

SPIRIT-LAMPS. Capital German ones can now be

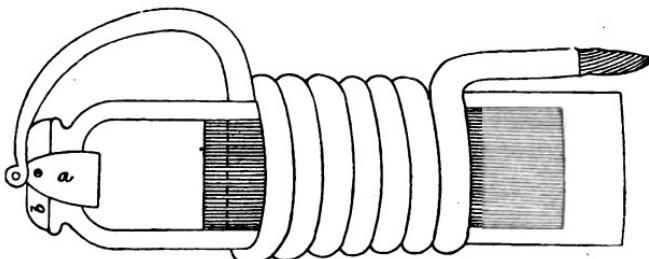


Fig. 43.

purchased at Griffin's for a shilling, and impure native spirit can (unfortunately) be now obtained in most savage

SPECTRUM LINES.

SPECTRUM LINES OF THE MOST IMPORTANT FLAME-COLOURING ELEMENTS.

FROM PROF. ROSCOE, F.R.S.

countries where our enterprising people or missionaries have been, which, redistilled in the portable still before described (see GLASS STILL), burns very well. I have often used the Indian naphtha called *mowa* in this way, and devised a bottle spirit-lamp, to which the wick itself fastened to a vulcanite stopper, when pulled out and wrapped round the bottle, forms a protection as well as keeping it firmly closed in travelling (see fig. 43).

STEEL MORTAR. (See ANVIL MORTAR.)

STRONTIUM, to detect. (1.) Hold a calcined fragment of the assay, or, if it decrepitate, a platinum wire ring full of the paste, over the base of a perfectly blue candle or lamp pyroccone, and rapidly touch the wick (see PYROCONE, ELLYCHNINE). A *violet-red* mantle surrounds the blue for a moment, repeated when the assay is recalcined. This tinge is easily distinguished from that afforded by lithia, from its containing less blue in it, and from that of lime, by having no orange. In the case of the mineral *Aragonite*, the paste in E.P. shows the small quantity of strontia present very clearly by the bluish-red tint at the *under side* of the base of the pyroccone, while the apex shows the brilliant red-orange of lime.

(2.) The assay calcined and cooled turns *deep blue* with a drop of Co. solution; and after some time in air, this colour changes to *brown* (diff. from lime.)

(3.) In H₂ strontia affords a *transparent borate ball*, almost identical with that of lime, but its specific gravity is greater.

SUBLIMATE, a. The word “Incrustation” seems creeping into use in some works instead of Sublimate. Now “Incrustation” implies (1) a *hard* covering, and (2)

a covering derived by the action of outer influences *from* the substance covered; as, *e.g.*, in the case of rust. "Pyroxide" would perhaps be a better term than any other.

SULPHUR, to detect. (1.) Mineral metallic sulphides (A. I. GENERAL COURSE) often burn in O.P., evolving the well-known smell of SO_2 . If sulphates of earthy bases are treated *per se* in H.P. on aluminium plate or spoon, the surface of the assay seems often reduced to a state of sulphide, for a drop of water applied to the hot mass generally affords the well-known smell of H.S., while the great effervescence caused by heating a portion of the centre in H.P. shows that part to be still a sulphate, though some sulphates, as *Barite* and *Celestine*, when treated on an aluminium spoon in a candle H.P. after being moistened with water, yield sulphur as a yellow incrustation.

(2.) Make a paste of the assay with a little moistened soda (potash is still better) on an agate slab, and treat the mass with a *candle* H.P. on bare aluminium plate. The resulting ball assumes when cool a *beautiful salmon colour*, pale or deep in proportion to the amount of S. present. Coal-gas, which must on no account be used, always affords a salmon-coloured ball. Sulphur can generally be detected this way, in a single hair of the beard.

(3.) The assay is fused with soda on charcoal, dug out with a penknife, and heated in H.P. with a drop of water on silver foil or silvered aluminium (see SILVER FOIL). A black and often iridescent stain of silver sulphide appears underneath (Berzelius).

(4.) Dissolve some copper oxide in a bead of H.P. by a P.P., so as to present the usual green-blue appearance. The assay is now dissolved in a candle H.P. in the bead,

which, if no sulphur is present, will change to green and remain clear and transparent; but if there is sulphur, or if a coal-gas pyrocone has been used, the reduced bead becomes dim and remains a "dirty" green. Sulphates are generally distinguished from sulphides or sulphites by their effervescence in H.P. under H.P., but V. Kobell recommends the following method:—Fuse the assay with caustic potash in a platinum spoon, and place the spoon with contents into water in which a strip of silver foil is immersed. A sulphide or sulphite blackens the silver; a sulphate does not.

SULPHUR as a reagent. Used with an HP bead to detect traces of boric acid, as in *Tourmaline* (see BORIC ACID). Crystallised sulphur is purest, and can be kept anywhere wrapped in a piece of paper.

TANTALUM, to detect. A few specks of the mineral *Columbite* from Haddam, Connecticut, applied to an HP bead under O.P., yield bluish-black amorphous fragments with white flocculent matter about them, like those of titanic acid; but these show through a powerful lens by reflected light a brilliant semi-metallic brown lustre, like *Avanturine*. A pin's-head fragment of pure (eggshell) lime produces a ball in this bead coloured greenish, evidently from iron protoxide, which might be thus separated, for the *Avanturine* fragments are at first unattacked. After continued O.P., however, they gradually dissolve in the ball, giving it a fine red-brown colour, like that of a cerium-borate ball; proved not to be due to manganese by its remaining constant in H.P., and by the different colour given to a calciborate ball by that oxide combined with iron, as in *Franklinite*. The red-brown calciborate ball, then, seems an

excellent test for tantalic and columbic acids when together. (See NIOBIUM.)

TELLURIUM burns with a smell at first like that of selenium, but in cooling, the smell changes to that of burning hair or skin. On aluminium plate *per se*, it affords a halo having a black or greyish-black nucleus with a white border which rises three inches and slightly coats the steel forceps. The scraped-off white sublimate instantly turns black on the application of a hot H_2 bead, but not of an H_3 one. The smallest portion, however, taken up on the latter causes the bead to become dark-brown on cooling, and attacks the platinum wire far more forcibly than arsenic in a similar bead.

THERMOCHROMATISM, or HEAT COLORATION.

As Mr. Ackroyd, F.C.S., &c., did me the honour, quite unintentionally, to attempt to explain in public my views on this subject better than I could do myself, I now place both explanations (from the *Chemical News* of 8th September 1876) side by side, and leave the student to digest whichever he likes best.

" The term 'thermochromatism' would seem more suitable for this class of phenomena than that proposed by Mr. Ackroyd, while I cannot but think that the intolerable confusion between ideas of function and of form, implied by his other term 'metachrome,' should be carefully avoided.

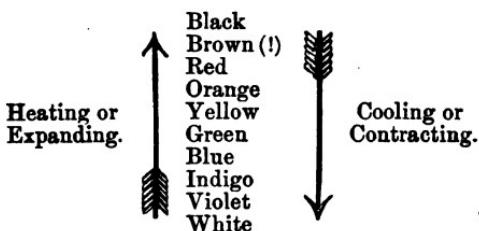
" Although Mr. Ackroyd has not made the faintest reference to the article on colour in my published work under mentioned, which, according to Mr. Valentin, led to his investigations, he has, notwithstanding, done me the honour, under the disguise of a cloud of high-sounding but rather pedantic and frothy phrases, as 'atomic potentiality,' &c., to come in the end to precisely the same conclusions as those recorded in my work; and to make this fact apparent, I give the following quotations:—

"PYROLOGY," p. 114 (1875).

"Substances whose particles can be agitated by vibrations of any kind, however minute, must have spaces between these, or pores; and if we can imagine vibrations having different amplitudes, it would not be difficult to assume the fact of pores having a corresponding magnitude, into some of which, for instance, waves of a comparatively greater amplitude, as red, could not pass, while violet vibrations would be freely admitted. If, then, we conceive an *expansion* of such light-pores by heat, the rays of greater amplitude (of vibration) would pass into the *hot* body and be gradually excluded as that cooled. It is a curious fact, with regard to this hypothesis, that oxide of bismuth—a metal which *expands* in cooling—proceeds in the other chromatic direction in cooling, viz., from yellow to white.' This description is illustrated by a coloured lithograph (Plate ii. of the work) representing a circular chromatic scale of the prismatic colours, with Fraunhofer's lettering, in which A, or red, exhibits the limit of coloured expansion, and H δ , or violetish-red, the limit of coloured contraction; and these limits are surrounded by dotted arrows, showing the progress of heated metallic oxides in either direction. White (as being the combination of all colours) concludes the scale at the limit of expansion, and black (as an absence of light) at that of contraction.

"MR. ACKROYD (1876).

"Hence when, at an early stage in its study, I saw that *nearly all metachromatic changes take place in a definite order—the order of the spectrum colours*—I was under the impression, even after much reading, that the subject was quite unworked. . . . Expansion by heat is an all but universal law, so far as we at present know. . . . Both classes (of oxides) alike owe their change to increased absorption of light, with elevation of temperature. . . . Reflecting upon these facts, we see that it is possible to arrange the colours in order, and this I have done as follows:—



"From the foregoing observations we learn (1) that metachromatism arises from increased absorption of light, with elevation of temperature, the more frangible increment increasing at a greater rate than the less refrangible; (2) that the only necessary concomitant is alteration of atomic potentiality; a change from the violet towards the red end of the metachromatic scale signifying atomic recession (pores expanding), and a change from the red towards the violet, atomic approach (pores contracting)."

"In my work *Pyrology*, above referred to, I have shown, both literally and graphically, how a solution of gold in phosphoric acid passes, in cooling, through all the prismatic colours from yellowish-orange to bluish-violet, and yet Mr. Ackroyd tells us he was the first 'to see, at an early stage of study, that nearly all the changes take place in the order of the spectrum colours' (!).

"I fear Mr. Ackroyd will find few scientific men, nowadays, willing to confirm or allow his extraordinary assertion that 'vibratory motion has little or nothing to do with the increased absorption of light by hot bodies,' or that 'black' is 'a colour,' or that 'brown' is a 'spectrum (prismatic) colour.'

"Stahl is evidently, though unadmittedly, cited by Mr. A. at second-hand, but I should feel obliged by information as to what part of his works 'connects colour change with the varying amounts of phlogiston a body contains when heated.' The observations of Stahl, with reference to the colours of heated bodies, seem to have been confined to iridescence ('evanescens colores variosa circa capellam formet qui ultimo iridis speciem præbebunt,' &c.—*Fundamenta Chymiae*, vol. i. p. 162), and to the change of colour metals experience in alloys ('Per fusionem varie mixturae metallicæ formantur, et interdum quidem pro certi coloris gradu obtinendo,' &c.—*Ibid.*, vol. iii. p. 187)."

THORIUM. The following is a qualitative assay of *Thorite* from Norway.* (1.) A reddish fragment, crushed to fine powder with a drop of water, has a slight smell of wetted alumina.

(2.) In H.B dissolves rapidly like an alkali to a very vitreous bead ; green pyrochrome slightly orangued.

(3.) When (2) is vesiculated and breathed on, a cloud, not blue like that of potash, is afforded, which vanishes rapidly near a spirit-lamp flame.

(4.) A speck of cobalt oxide affords a ball as usual in this bead, but, on touching the wire, bursts to a purple glassy mass which vanishes on continued O.P. in the bead, leaving no perceptible colour.

(5.) The bead (4) has a styptic taste like alum, but not so unpleasant. Silica is utterly insoluble, but alumina slightly soluble in this bead. Fresh *Thorite* powder gives the same results, only is much more difficultly dissolved in this bead. To detect *Thorium*, then, the very remarkable reactions (2) and (4) seem sufficient.

TIN, to detect. (1.) The two ores of this metal (*Cassiterite* and *Stannite*) readily betray its presence by the immediate snow-white efflorescence of the dioxide under O.P. on bare aluminium plate. The oxide (*Cassiterite*) further "sweats" minute balls of tin when thus treated with H.P., which are distinguished from those similarly produced from bismuthic ores, by not appearing nearly so quickly as the latter, and not affording a sublimate (see *BISMUTH*).

(2.) Paste of the crushed ore is plastered with a penknife above and below some pure (proof) lead in a keyhole

* Kindly given me by Dr. Foster, H.M.'s Inspector of Mines, Cornwall.

mortar on aluminium plate, and the mass fused in O.P. until the mortar is burned away. The upper or white part of the sublimate is then gently scraped off the aluminium with a penknife, and applied to a red-hot $\ddot{\text{H}}$ glass in O.P. Stannic acid apparently (?) causes the clear plumborate bead to remain *slightly opalescent on cooling*. Stannic dioxide remains as *insoluble white fragments* in the opalescent glass. This is *clarified* by an excess of fresh pure $\ddot{\text{H}}$ —by making a bead of the glass in fact—by which means plumbostannic pyroxide can be distinguished from plumbosilicic and plumbocalcic sublimes, which also afford in $\ddot{\text{H}}$ a glass slightly opalescent with white insoluble fragments, but are *not* clarified by the addition of $\ddot{\text{H}}$.

(3.) A drop of cobalt solution heated in O.P. on tin dioxide turns it *green*, darker than the green colour thus given to pyroxide of zinc but not dissimilar. The safest treatment therefore is to subject the cobaltine assay to O.P. on charcoal slip on Al. plate, when any coating on the former would belong to the tin and on the latter to the zinc.

TITANIUM, to detect. (1.) A trace of the dioxide affords to an $\ddot{\text{H}}$ bead a *fine amethyst* colour on cooling after H.P., which is not much affected by the presence of iron; but by the addition of sufficient soda to turn the bead to microcosmic salt, any iron present is shown by the amethystine colour changing to a brownish-yellow to brownish-red on cooling.

(2.) The lead-fuming process already described under *Tin* (2) is followed, and any insoluble fragments in the $\ddot{\text{H}}$ bead are dissolved and no more, by the cautious addition of specks of potassium carbonate. The presence of

titanic acid in this bead is proved, after the application to it of a short H.P., by its becoming dark-yellow with brown streaks like tortoiseshell, and with the H.P. continued a little longer, opaque white, with *pale-blue* streaks like some kinds of marble, and the part next the wire is *altogether blue*. If there is any quantity of titanium, the whole glass becomes *opaque turquoise-blue*. After a continued strong H.P. these glasses become clear but yellowish cold.

TUNGSTEN, *to detect.* (1.) Phosphoric acid is the proper detective reagent for this metal and its salts, with which it affords, B.B., a *pure sapphire-blue* colour. If 1 per cent. of the mineral *Wolframite* be ground into a paste with crystallised *Cassiterite* previously ascertained to be free from tungstic acid, and a trace of the mixture dissolved in a bead of H.P., quite an *azure* glass is obtained. Taking the percentage of tungstic acid and of tin in these ores respectively at 75.0, the amount of the former in the assay here rapidly detected would not have been more than .7 per cent., and if a fainter blue glass were held over faint-orange, even .1 per cent. of tungstic acid could be thus detected.

(2.) Fuse a large quantity of the powdered assay with potassium carbonate in O.P. on bare aluminium plate to an opaque-white or nearly white ball (*a*). Dissolve in another potassium carbonate bead as much phosphoric acid as will make it transparent cold (*b*). Now add (*a*) to (*b*) in H.P. A *turquoise-blue* colour shows the presence of tungstic acid.

URANIUM, *to detect.* (1.) Dissolve as much as possible of the powdered assay in a bead of H.P. in O.P. The bead

becomes *yellow (pea) green* on cooling. With the ordinary blowpipe beads, this green is confounded with that afforded by iron salts, but there is no fear of this in $\text{H}\ddot{\text{P}}$, which affords with iron a blood-red colour. The uranium green is easily distinguished from the pure green of chromium sesquioxide, or of vanadic acid in the same reagent; still more easily from the beautiful blue-green of molybdic acid in $\text{H}\ddot{\text{P}}$.

(2.) But if any doubt arises from the presence of other metallic oxides in the bead, the most certain plan is to apply the spectroscope (see BANDS, ABSORPTION), when the characteristic absorption bands of uranium in the green are observed.

VANADIUM, to detect. (1.) A trace of the powdered assay dissolved in an $\text{H}\ddot{\text{P}}$ bead by H.P. affords a *pure green*, distinguished from that of chromium by its easier solution, and by the change of the bead to yellow in O.P., and from uranic green as above.

(2.) *Vanadic acid*, in fine powder, obtained nearly pure by volatilising the lead, &c., exhaustively from a fragment of *Vanadinite* on aluminium plate, afforded in $\text{H}\ddot{\text{B}}$ *black opaque balls*. When treated as small specks in a strong O.P., large fragments of it remained unaltered.

VESICULATION, to effect.
The bead when red hot, is rapidly removed from the py-

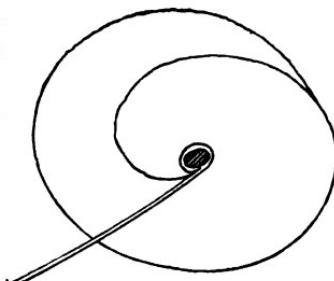


Fig. 44.

rocone and blown into through a mouth blowpipe having a jet with an orifice not less than this (o); a Gahn's blow-

pipe, with the platinum jet taken off, answers the purpose well. If the bead be not too cold, the result is that the hot fluid mass is blown out into a thin vesicle, iridescent, of course, in proportion to its thinness, about seventy times the size of the bead (fig. 44); thus presenting a very large surface of the dissolved oxide to be operated on, enabling the operator to detect and extract minute balls, metallic or borate, and affording *extremely* thin transparent plates of solutions for microscopical investigation.

WATER, CHEMICAL. (1.) Treat the hydrate in an HB bead under O.P. If decomposed, a *water-gruel-like opacity* indicates chemical water, as in the case of calcium hydrate, which thus renders the bead opaque, and yet affords a calcium-borate ball of the proper proportions by weight.

(2.) All hydrates afford an *orange pyrochrome* in O.P. until the water is driven off. Exceptions: chromatising substances, as boric acid. (See SODIUM.)

YTTRIUM, to detect. In HB, a few specks of fine dust of the calcined powder of Görlitz yttria give to O.P. *white stearic fragments* with flocculent matter round them, which do *not* attack calcium-borate balls, but, on the contrary, are dissolved in them, affording to a spectroscope bands at D and Eb (see Table I.). Unfortunately, the few minerals containing yttria, as *Gadolinite*, contain also cerium, which always affords absorption bands in about the same place. However, the great point for the student is to distinguish between these rare earths and alumina, which decomposes calcium borates in HB, while the former do not.

ZEOLITIC SILICATES, to analyse. Although against the rule of this work, which is *not* to particularise minerals or any other class of subjects for pyrological analysis, an

exception is here made in favour of zeolitic silicates, because they form such admirable and (once) difficult examples of the modern use of the blowpipe in determining and even separating the constituents of complex compounds. When I was baffled for some two years by the appearance of an "icy mass" presented in a bead of boric acid, B.B., by minerals which I knew to contain *lime*, I little thought that this puzzling circumstance would save the chemist and mineralogist a world of trouble and much valuable time by showing him, *in a few seconds* from one simple operation, the presence of silica, alumina, and alkali in the subject of his analysis, in which another simple operation would, almost as quickly, determine the presence of lime as borate balls, should any exist there.

In order to examine these silicates by means of boric acid, the operator has first to crush some fragments between agates to a fine powder, and treating, B.B., a trace of this powder taken up on the hot bead at the point of the blue pyrocone, to observe—

- (a.) If the fused powder forms a transparent *icy mass* dissolving eventually to a clear bead.—Ex. *Labradorite*.
- (b.) If the fused powder forms a *milky matter*, rendering the bead opaque.—Ex. *Zoisite*.
- (c.) If the fused powder forms a *water-gruelly* matter, with *balls* opaque or clear.—Ex. *Apophylite*.

In the case of (a) the operator may rest assured that he has here an *alkaline aluminous silicate*, which may or may not contain lime or magnesia,* &c. The only exception I know is *Harmotome*, in which baryta seems to act the part

* *Analcime* is a case of an icy mass, in the formation of which lime has no part.

of alkali. The distinction is easily made by adding a pin's-head fragment of lime (or a lime-borate ball, of which reagent a supply can be made and kept). In the *Har-motome* icy mass the lime ball floats uninjured, with hard well-defined edges. In the icy mass from, say *Labradorite*, the lime ball is at once decomposed into milky-white matter, which renders the bead opaque, like white enamel. There is another case of the lime ball remaining intact in the icy mass, *i.e.*, in that formed by *Lepidolite* powder, in which the lithia present seems to prevent the decomposing action of the alumina upon the lime. Examples of two of these three cases will shortly be given.

In the case of (*b*) the operator may be certain that there is a large proportion of *alumina* present with much or little lime—a matter easily determined by heating some fresh powder in a phosphoboric acid bead—*i.e.*, a boric acid bead which has been dipped hot into deliquesced phosphoric acid—when opaque-white balls will shortly appear, numerous and large in proportion to the quantity of lime present. As a saturated solution of pure alumina in a boric acid bead (made by means of a cautious addition of alkali) forms only grey or water-gruelly matter like silica, the *milky matter* of case (*b*) is obviously due to fine particles of milk-white lime disseminated through the bead from the decomposed lime-borate ball, so that this reaction is a proof of the presence both of alumina and lime in a mineral. In the case of a *salt*, where there is sufficient alkali to decompose the lime-borate ball, but not sufficient to re-dissolve the milky matter thus evolved, there may, of course, be no alumina present. To find if there is, crush the milk-white opaque

bead in the (*a*) forceps (*vide FORCEPS*) and apply some small fragments, B.B., to a fresh boric acid bead. If the milkiness was due to alumina, milkiness will again supervene in the fresh bead, *i.e.*, there will be no change; but if due to alkali without alumina, clear balls will immediately form, the alkali being taken up by the large proportion of fresh boric acid—an expected result.

In the case of (*c*), as in the result of applying the powder of such minerals as *Apophyllite*, *Wollastonite*, &c., to a boric acid bead, the operator sees at once that he has here a lime or lime-magnesian silicate *without* alumina, which may or may not contain alkali—a fact easily determined by the pyrochrome or coloured flame given by a fragment of the mineral *per se*, except as regards the presence of soda, because nearly all silicates thus give a yellow flame, but this point again is settled by the yellowing of the normal green boric acid pyrochrome, when we may be *quite certain* that soda is present.

The silicic acid is diffused as a water-gruelly matter through the bead, presumably on account of a shameful desertion by its former partner, lime, who, like a fickle Lothario, prefers boric acid to it in this temperature, while alumina seems more like a rival suitor for the attractions of the acid, with which, under great heat, it even attempts a kind of ball formation; at all events, it undoubtedly exercises, even when present in the most trifling proportion, a decomposing effect upon calcium borates in a bead of boric acid, which constitute therefore a most delicate test, qualitative and quantitative, for *alumina*.

I now proceed to give examples from my notes:—

No. 1. *Labradorite* (Sept. 1, 1878).

- (1.) A large trace L. powder to boric acid bead, B.B.
 (a.) A siliceous mass at first, changing after O.P. to an icy mass.

An aluminous alkaline silicate.

- (b.) More O.P. Glass clear and very vitreous.
 (2.) Boiled (1b) in Al. capsule,* to eliminate the alkali.
 (a.) Boiled to a thick, white, blanc-mangey jelly.
 (b.) Solution (acid) extracted by slips of blotting-paper placed over the capsule, like syphons.
 (3.) Residue white, jelly-like, thrown on agate slab, dried on platinum spatula, and treated in phosphorised boric acid bead.
 (a.) Creamy but bluish-white matter ; spreading.
 (b.) More O.P. Shining particles begin to appear.
 (4.) Vesiculated (3b). (See VESICULATION.)
 (a.) Several minute, clear, round *balls* : one—pretty large but egg-shaped—extracted from the vesicle by pliers and boiled in Al. capsule (*lime*).
 (b.) An irregular double or twin roundish mass, full of transparent particles (?). Bead water-gruelly.
 (5.) The oval mass (4b) in fresh boric acid bead.
 (a.) Became gradually opaque white ; then lost its rounded form, and became a fat-like mass with fringed edges (Al. phosphate ?).

[Thus we see that the effect of the alkali of *Labradorite* (which cannot be altogether removed) seems to be to cause

* These little aluminium capsules, made by Messrs. Griffin, require no spirit-lamp. A bead of boric acid is boiled down without stirring in one, before the blowpipe, in fifteen seconds.

a combination of the P_2O_5 with itself and the Al_2O_3 , leaving the lime free to effect a combination with the boric acid.]

No. 2. *Lepidolite* (Sept. 10, 1878).

(1.) *Appearance*.—Scales like those of mica.

(a.) Obtained a fine powder by rubbing several scales on a file, and tapping gently on an agate slab.

(2.) Trace of this powder in a boric acid bead, B.B.

(a.) A siliceous mass, dissolving to a clear vitreous, yellowish bead—yellow hot.

An alkaline aluminous silicate, with iron.

(b.) Pyrochrome of the bead green, unchanged.

Alkali not soda.

(3.) Vesiculated (2a), breathed on the vesicle, and re-heated in O.P.

(a.) An intense green fluorescent light.

Presence of fluorine.

(4.) Fragment of lime applied, B.B., to (3a).

(a.) Hard-outlined clear ball, with slight water-gruelly matter round : no milky matter.

Shows that a barium or lithium aluminous silicate is present.

(5.) Fragment of baryta applied, B.B., to (4a).

(a.) Bead almost immediately milk-white opaque ; clear hot. Barium-borate ball completely decomposed.

Considerable proportion of alumina.

(b.) Vesiculated ; no balls observable.

(6.) Fresh L. powder, dissolved, B.B., in boric acid ; the bead boiled ; the residue washed, dried, and heated, B.B., in phosphorised boric acid bead.

(a.) No balls ; vesiculated, no balls.

Absence of lime, magnesia, &c.

(7.) A scale of L. heated in Pt. forceps, and touching the wick of a pyrological candle, dyed the whole pyrocone a deep-crimson colour.

Presence of lithia.

(8.) L. powder dissolved in phosphoric acid, B.B., and the cold bead held over the base of a gas pyrocone.

(a.) A temporary but distinct violet tinge.

Presence of potash.

N.B.—This is a new test for potash, showing it even in presence of soda.

ZINC, to detect. (1.) Treat a trace of the finely-powdered assay under O.P. in an HB bead. A very remarkable reaction is afforded which cannot be mistaken for anything else, in the shape of *numerous minute clear balls floating in a semi-opaque mucous sac*, like boiled sago or frog spawn. If there is only a very trifling quantity of zinc oxide, combined with that of other borate-ball forming metals, the bead is to be boiled in an aluminium capsule, all other balls picked out with pliers, and the water, &c., evaporated to a pasty residue, which is scraped out, placed on an agate slab, and taken up in a fresh HB bead, when the sago-like reaction is afforded by the most trifling proportion of zinc.

(2.) Fuse some paste of the crushed assay (as *Calamine*), covered with a little sodium carbonate, in a charcoal mortar by a good H.P. along with a pin's-head ball of pure copper, so that there is as little sublimate as possible on the aluminium plate behind. Then take the alloy ball out of the hot fluid mass with pliers, and heat it strongly in H.P. on the bare plate. Some *spots of brass* are seen by a lens on the *under surface* of the ball.

(3.) The fragment of a sulphide as *Sphalerite*, heated on

a slip of copper resting on aluminium in O.P., immediately evolves a *velvety-black* sublimate on the plates, and turns a brilliant *canary-yellow* on its own surface, which colour is unchanged by a strong O.P.—a phenomenon which has every appearance of being due to electric action.

(4) Treat the assay on charcoal slip on Al. plate in O.P. A white sublimate covers the plate, which is *yellow while hot*, unchanged in H.P., and affords the reaction (1) in HB.

ZIRCONIUM, to detect. Pure zirconia (a greyish-white powder) behaves in a curious manner in HB, producing a slight milky matter with a calcium-borate ball, yet not apparently attacking it, and affording minute transparent crystals to the ball through a powerful lens, as silica does. Indeed, from its reactions with HB, zirconia would seem to be a strange link between silica and alumina. The transparent solutions of yttria and zirconia in calcium-borate balls have, however, considerable optical differences in the micropolariscope, which are beyond the scope of this treatise.

